

American National Standard Dimensional Tolerances for Aluminum Mill Products

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American National Standard

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Foreword

This Standard is a revision of ANSI H35.2(M)-2006, which consists of logical values for long-term metric use rather than a restatement of ANSI H35.2 in metric terms. This revision consists of modified foil and sheet definitions.

ANSI H35.2(M)-2009

American National Standard

Dimensional Tolerances for Aluminum Mill Products

1. Definitions

Bar—A solid wrought product that is long in relation to its cross section which is square or rectangular (excluding plate and flattened wire) with sharp or rounded corners or edges, or is a regular hexagon or octagon, and in which at least one perpendicular distance between parallel faces is over 10 mm.

Fin Stock—Coiled sheet or foil in specific alloys, tempers, and thickness ranges suitable for manufacture of fins for heat-exchanger applications.

Foil—Generally, a rolled product rectangular in cross section of thickness equal to or less than 0.2 millimeters (Formerly 0.15 mm, changed to 0.2 mm for international harmonization). There is an overlap in the thickness range 0.15-0.2 mm defined for foil and sheet. Foil products in this gage range are supplied to foil product specifications.

Forging Stock—A wrought or cast rod, bar or other section suitable for forging.

Pipe—Tube in standardized combinations of outside diameter and wall thickness, commonly designated by “Nominal Pipe Sizes” and “ANSI Schedule Numbers.” (Note: Larger sizes usually greater than 25 millimetres are typically extruded while smaller sizes are typically drawn.)

Plate—A rolled product that is rectangular in cross section and with thickness over 6.3 millimetres and with sheared or sawed edges.

Tread Plate—Sheet or plate having a raised figured pattern on one surface to provide improved traction.

Profile—A wrought product that is long in relation to its cross-sectional dimensions which is of a form other than that of sheet, plate, rod, bar, tube, wire or foil.

Structural Profile—A profile in certain standard alloys, tempers, sizes, and sections, such as angles, channels, tees, zees, I-beams, and H-sections, commonly used for structural purposes. For channels and I-beams there are two standards, namely Aluminum Association Standard and American Standard.

Rod—A solid wrought product over 10 mm in diameter that is long in relation to cross section and over 10 millimetres in diameter.

Shape—This term is no longer recommended. The term “Profile” is preferred. See “Profile.”

Sheet—Generally, a rolled product that is rectangular in cross section with thickness greater than 0.15 millimeters and less than 6.3 millimeters and with slit, sheared or sawed edges. There is an overlap in the thickness range 0.15-0.2 mm defined for foil and sheet. Sheet products in this gage range are supplied to sheet product specifications.

Alclad Sheet—Composite sheet comprised of an aluminum alloy core having on both surfaces (if one side only,

Alclad One Side Sheet) a metallurgically bonded aluminum or aluminum alloy coating that is anodic to the core, thus electrolytically protecting the core against corrosion.

Brazing Sheet—Sheet of a brazing alloy, or sheet clad with a brazing alloy on one or both sides.

Duct Sheet—Coiled or flat sheet in specific tempers, widths and thicknesses, suitable for duct applications.

Tube—A hollow wrought product that is long in relation to its cross section, which is symmetrical and is round, a regular hexagon or octagon, elliptical, or square or rectangular with sharp or rounded corners, and that has uniform wall thickness except as affected by corner radii.

Heat-Exchanger—Tube used for use in apparatus in which fluid inside the tube will be heated or cooled by fluid outside the tube. The term usually is not applied to coil tube or tubes for use in refrigerators or radiators. (Note: This product is typically seamless drawn tube.)

Welded Tube—A tube produced by forming and seam-welding sheet longitudinally.

Wire—A solid wrought product that is long in relation to its cross section, which is square or rectangular with sharp or rounded corners or edges, or is round, hexagonal, or octagonal, and whose diameter or greatest perpendicular distance between parallel faces is up through 10 millimetres.

2. Standard Limits for Expressing Tolerances

2.1 Standard limits for expressing the tolerances depend on the type of instrument ordinarily used in measuring the particular dimension. Where instruments permitting the required degree of accuracy generally are used, the tolerances are expressed in decimals as follows (except for foil):

Tolerance less than 0.050 mm	multiple of 0.005 mm
Tolerance over 0.050 mm thru 0.50 mm	multiple of 0.01 mm
Tolerance over 0.50 thru 1.00 mm	multiple of 0.02 mm
Tolerance over 1.00 mm	multiple of 0.05 mm

For measurements commonly made with instruments not permitting such accuracy, standard dimensional tolerances are expressed as follows:

Tolerance up thru 5 mm	multiple of 0.5 mm
Tolerance over 5 mm thru 50 mm	multiple of 1 mm
Tolerance over 50 mm	multiple of 5 mm

2.2 Rounding For purposes of determining conformance to the dimensional tolerances, a measured value is not rounded off. To determine applicable limits when a dimension is specified to more decimal places than are used in these standards, it shall be rounded off to the same number of places in conformance with ASTM E29, Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications.

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Aluminum Mill Products

7. Sheet and Plate

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7. Sheet and Plate

TABLE 7.7a Sheet and Plate Thickness Tolerances ^① (Applicable to All Alloys Not Included in the Aerospace Alloys Table 7.7b or Not Specified for Aerospace Applications)

NOTE: ALSO APPLICABLE TO ALLOYS WHEN SUPPLIED AS ALCLAD.

SPECIFIED THICKNESS, mm		SPECIFIED WIDTH—mm							
		Up thru 1 000	Over 1 000 Thru 1 500	Over 1 500 Thru 2 000	Over 2 000 Thru 2 500	Over 2 500 Thru 3 000	Over 3 000 Thru 3 500	Over 3 500 Thru 4 000	Over 4 000 Thru 4 500
Over	Thru	TOLERANCES—mm plus and minus							
0.15	0.40	0.025	0.040	..	..	..	..	..	..
0.40	0.63	0.040	0.050	0.08	0.09	..	..	..	..
0.63	0.80	0.045	0.06	0.09	0.10	..	..	..	..
0.80	1.00	0.050	0.08	0.09	0.11	0.15	..	..	..
1.00	1.20	0.06	0.09	0.11	0.14	0.18	0.20	..	..
1.20	1.60	0.08	0.09	0.13	0.15	0.18	0.23	..	..
1.60	2.00	0.09	0.10	0.14	0.18	0.20	0.25	..	..
2.00	2.50	0.09	0.11	0.15	0.18	0.23	0.28	..	..
2.50	3.20	0.11	0.14	0.18	0.23	0.28	0.33	..	..
3.20	4.00	0.14	0.18	0.23	0.28	0.33	0.38	..	..
4.00	5.00	0.18	0.23	0.28	0.33	0.38	0.46	..	..
5.00	6.30	0.23	0.28	0.33	0.38	0.46	0.56	0.69	..
6.30	8.00	0.30	0.36	0.38	0.46	0.56	0.69	0.89	1.10
8.00	10.00	0.38	0.43	0.51	0.58	0.69	0.84	1.05	1.30
10.00	16.00	0.58	0.58	0.69	0.81	0.89	1.10	1.35	1.65
16.00	25.00	0.79	0.79	0.94	1.10	1.20	1.45	1.80	2.15
25.00	40.00	1.00	1.00	1.20	1.40	1.65	1.90	2.30	2.65
40.00	60.00	1.40	1.40	1.55	1.80	2.45	2.55	2.90	..
60.00	80.00	1.90	1.90	2.15	2.55	2.65	3.20	..	..
80.00	100.00	2.55	2.55	2.90	3.20	3.30	4.00	..	..
100.00	160.00	3.30	3.30	3.70	4.20	..	..	..	..

TABLE 7.7b Sheet and Plate Thickness Tolerances ^① (Applicable to All Alloys Specified for Aerospace Applications)

(INCLUDES AEROSPACE ALLOYS 2014, 2024, 2124, 2219, 2324, 2419, 7050, 7075, 7150, 7178 and 7475)

NOTE: ALSO APPLICABLE TO ALLOYS WHEN SUPPLIED AS ALCLAD.

SPECIFIED THICKNESS, mm		SPECIFIED WIDTH—mm											
		Up thru 1 000	Over 1 000 thru 1 200	Over 1 200 thru 1 400	Over 1 400 thru 1 500	Over 1 500 thru 1 800	Over 1 800 thru 2 000	Over 2 000 thru 2 200	Over 2 200 thru 2 500	Over 2 500 thru 3 000	Over 3 000 thru 3 500	Over 3 500 thru 4 000	Over 4 000 thru 4 500
Over	Thru	TOLERANCE—mm plus and minus											
0.15	0.25	0.035	0.06	0.06	0.06	..	..	..	..	..	..	..	..
0.25	0.40	0.040	0.07	0.07	0.07	..	..	..	..	..	..	..	..
0.40	0.63	0.040	0.07	0.07	0.07	..	..	..	..	..	..	..	..
0.63	0.80	0.040	0.040	0.06	0.08	0.08	..	..	..	..	..	..	..
0.80	1.00	0.040	0.040	0.06	0.08	0.08	0.10	0.10	0.20	..	..	..	..
1.00	1.20	0.050	0.050	0.06	0.08	0.08	0.10	0.10	0.22	0.26	0.30	..	..
1.20	1.60	0.050	0.050	0.08	0.08	0.08	0.10	0.10	0.24	0.30	0.34	..	..
1.60	2.00	0.050	0.050	0.08	0.09	0.09	0.10	0.10	0.26	0.34	0.40	..	..
2.00	2.50	0.065	0.065	0.09	0.11	0.11	0.12	0.12	0.30	0.38	0.46	..	..
2.50	3.20	0.09	0.09	0.10	0.12	0.12	0.12	0.12	0.34	0.42	0.52	..	..
3.20	4.00	0.11	0.11	0.12	0.18	0.18	0.25	0.25	0.40	0.48	0.58	..	..
4.00	5.00	0.15	0.18	0.18	0.23	0.23	0.30	0.30	0.46	0.56	0.66	..	..
5.00	6.30	0.24	0.32	0.32	0.32	0.44	0.44	0.54	0.54	0.64	0.76	..	..
6.30	8.00	0.32	0.40	0.40	0.40	0.50	0.50	0.62	0.62	0.74	0.86	1.05	1.30
8.00	10.00	0.44	0.46	0.46	0.46	0.58	0.58	0.72	0.72	0.86	1.00	1.20	1.50
10.00	16.00	0.60	0.60	0.60	0.60	0.72	0.72	0.86	0.86	1.00	1.20	1.50	1.80
16.00	25.00	0.80	0.80	0.80	0.80	0.94	0.94	1.10	1.10	1.30	1.55	1.90	2.20
25.00	40.00	1.00	1.00	1.00	1.00	1.20	1.20	1.40	1.40	1.65	1.95	2.30	2.70
40.00	60.00	1.40	1.40	1.40	1.40	1.60	1.90	1.90	1.90	2.30	2.60	3.00	..
60.00	80.00	2.00	2.00	2.00	2.00	2.10	2.10	2.80	2.80	3.30	3.30	..	..
80.00	100.00	2.60	2.60	2.60	2.60	2.95	2.95	3.40	3.40	3.90	4.10	..	..
100.00	160.00	3.40	3.40	3.40	3.40	3.80	3.80	4.30	4.30	..	..	..	..

Note: Capability to provide tighter tolerances may vary with supplier.
^① When a dimension tolerance is specified other than as equal bilateral tolerance, the value of the standard tolerance is that which applies to the mean

of the maximum and minimum dimension permissible under the tolerance for the dimension under consideration.

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TABLE 7.8 Width Tolerances—Sheared Flat Sheet and Plate

SPECIFIED THICKNESS mm		SPECIFIED WIDTH—mm						
		Up thru 250	Over 250 thru 500	Over 500 thru 1 000	Over 1 000 thru 2 000	Over 2 000 thru 3 000	Over 3 000 thru 4 000	Over 4 000 thru 5 000
Over	Thru	TOLERANCES ②—mm						
0.15	3.20	±1.5	±2	±2.5	±3	±4	±4.5	..
3.20	6.30	±2	±2.5	±3	±3.5	±4.5	±5	..
6.30	12.50	+6	+7	+8	+9	+11	+12	+14

TABLE 7.9 Length Tolerances—Sheared Flat Sheet and Plate

SPECIFIED THICKNESS mm		SPECIFIED LENGTH—mm										
		Up thru 1 000	Over 1 000 thru 2 000	Over 2 000 thru 3 000	Over 3 000 thru 4 000	Over 4 000 thru 5 000	Over 5 000 thru 7 500	Over 7 500 thru 10 000	Over 10 000 thru 12 500	Over 12 500 thru 15 000	Over 15 000 thru 17 500	Over 17 500 thru 20 000
Over	Thru	TOLERANCES ②—mm										
0.15	3.20	±2	±2.5	±3	±3	±3.5	±4.5	±5	±6	±7	±8	..
3.20	6.30	±2.5	±3	±3	±3.5	±4	±5	±6	±7	±8	±9	..
6.30	12.50	+8	+9	+10	+10	+11	+13	+14	+16	+18	+19	+21

TABLE 7.10 Width and Length Tolerances—Sawed Flat Sheet and Plate

SPECIFIED THICKNESS mm		SPECIFIED WIDTH AND LENGTH—mm										
		Up thru 1 000	Over 1 000 thru 2 000	Over 2 000 thru 3 000	Over 3 000 thru 4 000	Over 4 000 thru 5 000	Over 5 000 thru 7 500	Over 7 500 thru 10 000	Over 10 000 thru 12 500	Over 12 500 thru 15 000	Over 15 000 thru 17 500	Over 17 500 thru 20 000
Over	Thru	TOLERANCES ②—mm										
2.00	6.30	±3	±3	±4	±4	±5	±6	±7	±8	±9	±10	±11
6.30	160.00	+6	+7	+8	+9	+10	+12	+14	+16	+18	+20	+22

TABLE 7.11 Width Tolerances ①—Slit Coiled Sheet

SPECIFIED THICKNESS mm		SPECIFIED WIDTH—mm							
		Up thru 150	Over 150 thru 250	Over 250 thru 500	Over 500 thru 750	Over 750 thru 1 000	Over 1 000 thru 1 500	Over 1 500 thru 2 000	Over 2 000 thru 2 500
Over	Thru	TOLERANCES ②—mm plus and minus							
0.15	3.20	0.25	0.5	1	1	1	1.5	2.5	3.5
3.20	5.00	..	1	1	1	1.5	2	3	..
5.00	6.30	..	1	1	1.5	2	3	4	..

TABLE 7.12 Lateral Bow Tolerances ①—Coiled Sheet

SPECIFIED THICKNESS mm		SPECIFIED WIDTH—mm				
		12 thru 25	Over 25 thru 50	Over 50 thru 100	Over 100 thru 250	Over 250
Over	Thru	TOLERANCE—mm in 2 000 mm Allowable Deviation of a Side Edge from a Straight Line				
0.15	1.60	20	15	10	6	5
1.60	3.20	..	..	10	6	5

For all numbered footnotes, see page 12.

TABLE 7.13 Lateral Bow Tolerances—Flat Sheet and Plate

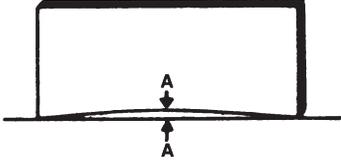
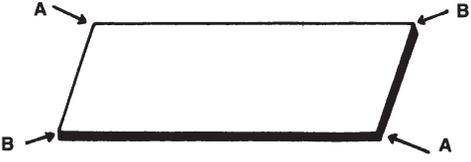
SPECIFIED THICKNESS mm		SPECIFIED WIDTH mm		ALLOWABLE DEVIATION OF A SIDE EDGE FROM A STRAIGHT LINE					
				 <p>Maximum allowable value of AA</p>					
				SPECIFIED LENGTH—mm					
				Up thru 1000	Over 1000 thru 2000	Over 2000 thru 3000	Over 3000 thru 4000	Over 4000 thru 5000	Over 5000 thru 6000
Over	Thru	Over	Thru	TOLERANCE—mm					
0.15	3.20	..	100	3	11	25	45	70	100 ^⑤
		100	250	1	3.5	8	13	21	30 ^⑤
		250	900	1	2.5	5	9	14	30 ^⑤
		900	..	0.5	1.5	3	5	8	12 ^⑤
3.20	6.30	100	400	1	3	6	11	17	25 ^⑤
		400	..	0.5	1.5	3	5	8	12 ^⑤
6.30	150.00	..	250	3	11	25	45	70	100 ^⑤
		250	400	1	3	6	11	17	25 ^⑤
		400	..	0.5	2	3.5	6	10	14 ^⑤

TABLE 7.14 Squareness Tolerances—Flat Sheet and Plate

SPECIFIED LENGTH mm	SPECIFIED WIDTH—mm	
	Up thru 1 000	Over 1 000
	ALLOWABLE DIFFERENCE IN LENGTH OF DIAGONALS ^④ —mm	
	 <p>Maximum difference between AA and BB</p>	
Up thru 3 500	0.8 · each 100 mm segment of width ^③	0.7 · each 100 mm segment of width ^③
Over 3 500	1.2 · each 100 mm segment of width ^③	1.0 · each 100 mm segment of width ^③

① When a dimension tolerance is specified other than as an equal bilateral tolerance, the maximum value of the standard tolerance is that which applies to the mean of the maximum and minimum dimensions permissible under the tolerance for the dimension under consideration.

② Tolerances applicable at ambient mill temperatures. A change in dimension of 0.24 mm per metre per 10°C must be recognized.

③ If specified width is other than an exact multiple of 100 mm, tolerance is determined by using the next largest exact multiple. For example, if specified width is 750 mm and specified length is 2 800 mm, the tolerance is 0.8 mm · 8 = 6.4 mm. This result, if not a whole mm, is rounded to upward to the nearest mm.

④ Use values for calculating only. Round result upward to nearest mm.

⑤ Also applicable to any 6 000 mm increment of longer sheet or plate.

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TABLE 7.15 Diameter Tolerances—Sheared or Blanked Sheet and Plate Circles ①

Over Thru		SPECIFIED DIAMETER—mm					
		Up thru 500	Over 500 thru 1 000	Over 1 000 thru 2 000	Over 2 000 thru 3 000	Over 3 000 thru 4 000	Over 4 000 thru 5 000
SPECIFIED THICKNESS mm		ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER mm plus and minus					
							
		Difference between AA and specified diameter					
0.15	6.30	1	1.5	2.5	4	6	
6.30	12.50	..	2.5	3.5	5	7	9
12.50	25.00	..	6	7	9	11	13

TABLE 7.16 Diameter Tolerances—Sawed Sheet and Plate Circles ①

Over Thru		SPECIFIED DIAMETER—mm					
		Up thru 500	Over 500 thru 1 000	Over 1 000 thru 2 000	Over 2 000 thru 3 000	Over 3 000 thru 4 000	Over 4 000 thru 5 000
SPECIFIED THICKNESS mm		ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER mm plus and minus					
							
		Difference between AA and specified diameter					
2.00	25.00	3.5	4	5	6	8	11
25.00	50.00	5	6	8	10	13	16
50.00	100.00	8	10	12	15	18	21

TABLE 7.17 Flatness Tolerances—Flat Sheet ②

Alloy (Includes Alclads)	Specified Thickness mm		Longitudinal or Transverse Distance (mm) Center to Center of Buckles or Edge Waves ③				
			Up thru 500	Over 500 thru 1 000	Over 1 000 thru 1 500	Over 1 500 thru 2 000	Over 2 000
	Over	Thru	TOLERANCES, mm ④ ⑤ ⑥				
1060, 1100, 1350, 3003, 3005, 3105, 5005, 5050, 5X57	0.50	1.60	2	4	6	8	10
	1.60	6.30	3	5	8	10	13
3004, 5052, 5083, 5086, 5252, 5X54, 5456, 5652, brazing sheet, and all heat treatable alloys	0.50	1.60	4	6	9	11	14
	1.60	6.30	5	7	10	12	15

① When a dimension tolerance is specified other than as an equal bilateral tolerance, the maximum value of the standard tolerance is that which applies to the mean of the maximum and minimum dimensions permissible under the tolerance for the dimension under consideration.

② Not applicable to cut-to-length sheet, panel flat sheet, coiled sheet, or sheet over 1 500 mm wide. Flatness tolerances, including coil set flatness tolerances, for these excluded products, should be as agreed upon in

advance between producer and purchaser (See Section 5, Terminology, for a definition of Sheet, Coiled Cut-to-Length).

③ Also applicable to overall length or width of sheet if only one longitudinal and/or transverse buckle or edge wave is present.

④ Allowable deviation from flat with sheet positioned on flat horizontal surface to minimize deviation.

⑤ Not applicable to O, F and HX8 and harder tempers.

⑥ Not applicable to end or corner turnup.

TABLE 7.18 Flatness Tolerances—Sawed or Sheared Plate**LONGITUDINAL FLATNESS**

SPECIFIED THICKNESS, mm		TOLERANCE ^① mm—Allowable Deviation from Flat	
Over	Thru	TX51 tempers ^②	Other than TX51 tempers ^{② ⑦}
6.30	80.00	5 in any 2 000 mm ^③	7 in any 2 000 mm or less
80.00	100.00	3.5 in any 2 000 mm or less	7 in any 2 000 mm or less

TRANSVERSE FLATNESS

SPECIFIED THICKNESS, mm		TOLERANCE ^① in.—Allowable Deviation from Flat						
		Width—mm						
		Up thru 500	Over 500	Thru 1 000	Over 1 000	Thru 1 500	Over 1 500	Thru 2 000
Over	Thru	All tempers ^⑦	TX51 tempers ^②	Other than TX51 tempers ^{② ⑦}	TX51 tempers ^②	Other than TX51 tempers ^{② ⑦}	TX51 tempers ^②	Other than TX51 tempers ^{② ⑦}
6.30	16.00	Only short-span flatness tolerance applies	6	7	8	10	10	13
16.00	40.00		4	6	6	8	8	10
40.00	80.00		3	5	4	6	5	7
80.00	160.00		2.5	4	3	5	3.5	6

SHORT-SPAN FLATNESS ^⑤

SPECIFIED THICKNESS, mm		TOLERANCE ^⑥ mm—Allowable Deviation from Flat	
Over	Thru	TX51 tempers ^②	Other than TX51 tempers ^{② ⑦}
6.30	16.00	2.00	2.50
16.00	160.00	1.50	1.80

^① As measured with plate resting on a flat surface concave side upward, using a straightedge and a feeler gage, dial gage or scale.

^② TX51 is a general designation for the following stress-relieved tempers: T351, T451, T651, T851, T7351 and T7651.

^③ For lengths under 2 000 mm, the tolerance is 3.5 mm.

^④ For widths over 2 000 mm, these tolerances apply for any 2 000 mm of total width.

^⑤ Short-span flatness is the deviation from flat over full span for spans 500 mm and less.

^⑥ As measured with the plate resting on a flat surface.

^⑦ Not applicable to O, F, and HX8 and harder tempers.

Tables 7.19 – 7.25 intentionally blank

TABLE 7.26 Thickness Tolerances ^①—Commercial Roofing and Siding

NOMINAL THICKNESS mm	NOMINAL WIDTH—mm	
	Up thru 1000	Over 1000 thru 1500
	TOLERANCE—mm plus and minus	
0.60	0.06	0.10
0.80	0.07	0.11
0.90	0.08	0.12
1.0	0.08	0.12
1.2	0.10	0.13

TABLE 7.29 Parallelness of Corrugations—Commercial Roofing and Siding

PRODUCT	PARALLELNESS OF CORRUGATIONS
Corrugated roofing and siding	Capable of being lapped at either end.
V-beam roofing and siding	Capable of being lapped at either end.
Ribbed roofing	Capable of being lapped at either end and ribs are parallel to each other and to edges of sheet within ± 3 mm
Ribbed siding	Capable of being lapped at either end.

TABLE 7.27 Depth of Corrugation Tolerances—Commercial Roofing and Siding

Allowable deviation from nominal depth of corrugation: ± 1 mm

TABLE 7.30 Squareness—Commercial Roofing and Siding

Allowable difference in length of diagonals: ± 13 mm

TABLE 7.28 Length Tolerances ^②—Commercial Roofing and Siding

Allowable deviation from specified length: ± 13 mm

^① Applicable prior to painting, corrugating or embossing.

^② Applicable to lengths of 1 000 thru 9 000 mm for all products except ribbed siding. For ribbed siding, tolerances are applicable to lengths of 1 000 thru 11 000 mm.

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TABLE 7.31 Thickness Tolerances—Duct Sheet

STANDARD THICKNESS mm	TOLERANCE—mm plus and minus	
	STANDARD WIDTHS—mm	
	600, 750, 900	1 200
0.40	0.030	0.050
0.45, 0.50, 0.55, 0.60	0.040	0.06
0.80	0.045	0.07
1.0	0.050	0.08
1.2	0.06	0.09
1.6	0.08	0.10

TABLE 7.32 Width Tolerances—Flat Duct Sheet

STANDARD THICKNESS mm	TOLERANCE—mm plus and minus	
	STANDARD WIDTHS—mm	
	600, 750, 900	1 200
All	2.5	3

TABLE 7.33 Width Tolerances—Coiled Duct Sheet and Coiled Duct Sheet Cut to Length

STANDARD THICKNESS mm	TOLERANCE—mm plus and minus	
	STANDARD WIDTHS—mm	
	600, 750, 900	1 200
All	1	1.5

TABLE 7.34 Length Tolerances—Coiled Duct Sheet Cut to Length and Flat Duct Sheet

STANDARD LENGTH	STANDARD WIDTH	TOLERANCE, mm
All	All	±6

Table 7.35 intentionally blank

TABLE 7.36 Mass per Square Metre—Tread Plate

The following nominal masses per square metre are based on alloy 6061, which has a density of $2.70 \cdot 10^3$ kilograms per cubic metre:

THICKNESS mm	NOMINAL MASS kg/m ²
2.50	7.4
3.20	9.3
4.00	11.5
5.00	14.2
6.00	16.9
8.00	22.3
10.00	27.7
12.00	33.1
16.00	43.9

TABLE 7.37 Thickness Tolerances—Tread Plate

SPECIFIED THICKNESS ①—mm	TOLERANCE—mm	
	Plus ②	Minus
2.50	0.20	0.30
3.20	0.26	0.38
4.00	0.28	0.48
5.00	0.35	0.60
6.00	0.42	0.72
8.00	0.56	0.96
10.00	0.70	1.20
12.00	0.84	1.40
16.00	1.10	1.90

① Specified thickness does not include height of pattern.

② In case of dispute, allowed plus tolerance shall be determined by mass. The allowed deviation from nominal mass shall not exceed plus 8 percent.

TABLE 7.38 Width Tolerances—Tread Plate

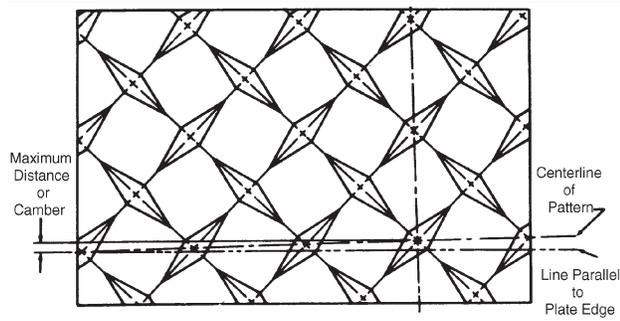
Allowable deviation from specified width: plus 10 mm

TABLE 7.39 Length Tolerances—Tread Plate

SPECIFIED LENGTH mm		TOLERANCE mm—plus
Over	Thru	
..	4 000	10
4 000	6 000	11
6 000	..	12

TABLE 7.40 Height of Pattern Tolerance—Tread Plate

Minimum height of raised pattern: 1.00 mm.
(Maximum height is controlled by weight tolerance.)

**TABLE 7.41 Camber of Pattern Line^④
Tolerances—Tread Plate**

SPECIFIED LENGTH mm		TOLERANCE—mm	
Over	Thru	SPECIFIED WIDTH—mm	
		Up thru 1 000	Over 1 000 thru 2 000
..	500	3	3
500	2 000	13	13
2 000	4 000	20	25
4 000	..	25	40

**TABLE 7.42 Lateral Bow^③ Tolerances—
Tread Plate**

SPECIFIED WIDTH mm		TOLERANCE—mm
		ALLOWABLE DEVIATION OF A SIDE EDGE FROM A STRAIGHT LINE
		SPECIFIED THICKNESS—mm
Over	Thru	2.50–16.00 mm
..	100	25 in any 3 000 mm
100	400	6 in any 3 000 mm
400	2 000	3 in any 3 000 mm

**TABLE 7.43 Squareness Tolerances^⑤—
Tread Plate**

SPECIFIED LENGTH mm		TOLERANCE—mm
Over	Thru	ALLOWABLE DIFFERENCE IN LENGTH OF DIAGONALS
		..
4 000	6 000	11
6 000	..	12

③ Applicable only to lengths up through 6 000 mm.

④ The camber of a pattern line is the maximum distance between the center of any figure in a pattern line and a line parallel with the edge of the plate that passes through the center of the figure in the same pattern line nearest to the edge of the floor plate.

⑤ Not required.

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8. Fin Stock

Table 8.1 intentionally blank

TABLE 8.2 Thickness Tolerances—Fin Stock

SPECIFIED THICKNESS mm		TOLERANCE mm plus and minus
over	thru	
0.10	0.25	0.013
0.25	0.40	0.025
0.40	0.80	0.038

TABLE 8.3 Width and Lateral Bow
Tolerances^①—Fin Stock

Same as for coiled sheet.

See Tables 7.11 and 7.12

Note: The Olsen Cup and similar tests frequently used as measures of formability are not sufficiently reproducible to permit the establishment of standards for acceptance or rejection of material. Cup test values, when used, are acceptable only as general guidelines for rating comparative formability.

^① Tolerances for thicknesses over 0.10 thru 0.15 mm are the same as those specified for thicknesses over 0.15 mm.

9. Foil

Table 9.1 intentionally blank

TABLE 9.2 Covering Area—Unmounted Foil

SPECIFIED THICKNESS mm	COVERING AREA—m ² /kg ①			SPECIFIED THICKNESS mm	COVERING AREA—m ² /kg ①		
	Nominal	Minimum ②	Maximum ②		Nominal	Minimum ②	Maximum ②
0.005	74.1	67.3	82.3	0.030	12.3	11.2	13.7
0.006	61.7	56.1	68.6	0.040	9.26	8.42	10.3
0.007	52.9	48.1	58.8	0.050	7.41	6.73	8.23
0.008	46.3	42.1	51.4	0.060	6.17	5.61	6.66
0.009	41.2	37.4	45.7	0.070	5.29	4.81	5.88
0.010	37.0	33.7	41.2	0.080	4.63	4.21	5.14
0.011	33.7	30.6	37.4	0.090	4.12	3.74	4.57
0.012	30.9	28.1	34.3	0.100	3.70	3.37	4.12
0.014	26.5	24.1	29.4	0.110	3.37	3.06	3.74
0.016	23.1	21.0	25.7	0.120	3.09	2.81	3.43
0.018	20.6	18.7	22.9	0.140	2.65	2.41	2.94
0.020	18.5	16.8	20.6	0.160	2.31	2.10	2.57
0.022	16.8	15.3	18.7	0.180	2.06	1.87	2.29
0.025	14.8	13.5	16.5	0.200	1.85	1.68	2.06
0.028	13.2	12.0	14.57				

① Based on a density of 2700 kg/m³, the density of 1145 and 1235 aluminum. Covering area in m²/kg is calculated using the following formula:

$$\text{Covering Area} = \frac{1000}{\text{thickness in mm.} \times \text{density in kg/m}^3}$$

Alloy	Density (kg/m ³)
1100	2710
1145	2700
1235	2705
3003	2730
5052	2680
5056	2640

② Based on the standard thickness tolerance of plus and minus 10% per roll or shipment.

TABLE 9.3 Roll Width—Unmounted Foil

SPECIFIED WIDTH mm		TOLERANCE—mm plus and minus	
Over	Thru	Unmounted Foil	Colored, Embossed and Coated Foil
..	300	0.5	1
300	..	1	1

TABLE 9.5 Length and Width—Flat Sheets of Unmounted Foil

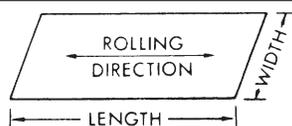
SPECIFIED LENGTH OR WIDTH mm	TOLERANCE—mm plus and minus
	 <p>The diagram shows a rectangular flat sheet of foil. A horizontal double-headed arrow across the top is labeled 'ROLLING DIRECTION'. A horizontal double-headed arrow at the bottom is labeled 'LENGTH'. A vertical double-headed arrow on the right side is labeled 'WIDTH'.</p>
All	1

TABLE 9.4 Inside Diameter—Core, Unmounted Foil

SPECIFIED INSIDE DIAMETER mm	TOLERANCE—mm plus and minus	
	Fiber Cores	Metal Cores
33	+1, -0.5	+0.5, -0
76	+1, -0.5	+0.5, -0

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TABLE 9.6 Splices—^① Unmounted Foil, Maximum Number per Roll

ROLL DIAMETER mm		FOIL THICKNESS—mm			
		0.008 thru 0.025		Over 0.025	
		FOIL WIDTH—mm			
over	thru	Up thru 1300 ^②	Over 1300	Up thru 1300 ^②	Over 1300
..	250	3	4	1	1
250	350	5	7	2	3
350	450	8	11	4	5
450	550	10	13	6	7
Maximum Average Number Per Roll in Total Shipment					
..	250	2	2	½	½
250	350	3	5	1	1
350	450	5	8	2	2
450	550	7	10	3	4

^① Standard splices are lap or butt made with foil or plastic tape. Other types are subject to special inquiry.

^② Maximum for 90% of shipment; remainder will not exceed maximums listed for widths over 1300 mm.

TABLE 9.7 Coating Weights—
Unmounted Foil

COATING TYPE	TOLERANCE percent plus and minus
Heat seal, Clear	20 or 0.5 g/m ² ^①
Polyethylene	15
Elvax	30

^① Whatever is greater.

TABLE 9.8 Quantity Tolerance—
Unmounted Foil

SPECIFIED QUANTITY Per Item or Order	TOLERANCE percent plus and minus
All	10

LAMINATED FOIL

TABLE 9.9 Roll Width—Laminated Foil

SPECIFIED WIDTH mm	TOLERANCE—mm plus and minus	
	Laminated Foil	Colored, Embossed and Coated Foil
Up thru 300	0.5	1
Over 300	1	1

TABLE 9.10 Inside Diameter—Core,
Laminated Foil

SPECIFIED INSIDE DIAMETER mm	TOLERANCE—mm plus and minus	
	Fiber Cores	Metal Cores
33	+1, -0.5	+0.5, -0
76	+1, -0.5	+0.5, -0

TABLE 9.11 Length and Width—Flat Sheets of
Unmounted Foil

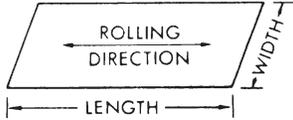
SPECIFIED LENGTH OR WIDTH mm	TOLERANCE—mm plus and minus
	
All	1

TABLE 9.12 Coating Weights—Laminated Foil

COATING TYPE	TOLERANCE percent plus and minus
Heat Seal, Clear	20 or 0.5 g/m ² ^①
Polyethylene	15
Elvax	30

^① Whatever is greater.

TABLE 9.13 Covering Area (Yield)—
Laminated Foil

NOMINAL COVERING AREA m ² /kg	TOLERANCE ^① percent plus and minus
All	10

^① Average per roll or shipment.

TABLE 9.14 Adhesive Weight—Laminated Foil

ADHESIVE TYPE	TOLERANCE percent plus and minus
Solid Glue, Asphalt Thermoplastic	20 or 0.5 g/m ² ^①
Wax	20
Polyethylene	15

^① Whatever is greater.

TABLE 9.15 Paper Weight—Ream Basis ^①

PAPER TYPE ^②	TOLERANCE percent plus and minus
All	5

^① As expressed in g/m² or Grammage

^② Some papers may require a greater tolerance.

**TABLE 9.16 Quantity Tolerance—
Laminated Foil**

SPECIFIED QUANTITY Per Item or Order	TOLERANCE percent plus and minus
All	10

PRINTED FOIL

TABLE 9.17 Border Width—Cut Labels

TYPE OF CUT	NOMINAL BORDER WIDTH mm min.
Rectangular Rhomboid or Die	3.5

TABLE 9.21 Minimum Type Size—Rotogravure

TYPE	LINE CYLINDER	STONE OR PROCESS
Relief	1.4 mm	2.1 mm
Reverse	2.1 mm	2.8 mm

TABLE 9.18 Overall Size—Cut Labels

SPECIFIED SIZE mm	TOLERANCE—mm plus and minus	
	Within a Shipment	Within a Pack
All	1	0.5

TABLE 9.22 Quantity Tolerance ^①

SPECIFIED QUANTITY mm		TOLERANCE Percent
over	thru	
..	500	+100, -50
500	5 000	±40
5 000	10 000	±35
10 000	15 000	±30
15 000	20 000	±25
20 000	25 000	±20
25 000	30 000	±15
30 000	..	±10

^① For body and neck labels ordered in equal sets and produced on combination cylinders see Table 9.24 for additional tolerance.

TABLE 9.19 Border Variation—Cut Labels

TYPE OF LABEL	TOLERANCE mm plus and minus
Unembossed or Full Embossed	1
Embossed to Register	1.5

TABLE 9.23 Covering Area (Yield) ^①

NOMINAL COVERING AREA m ² /kg	TOLERANCE percent plus and minus
All	10

^① Average per roll or shipment

TABLE 9.20 Width—Rolls

SPECIFIED WIDTH mm	TOLERANCE mm plus and minus
All	1

**TABLE 9.24 Quantity Variation Between
Body and Neck Labels**

When ordered in equal sets, the allowable deviation in the number of body and neck labels when produced on combination cylinders is 10 percent.

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10. Wire, Rod, and Bar—Rolled or Cold-finished

Tables 10.1 —10.4 intentionally blank

TABLE 10.5 Diameter—Round Wire and Rod

SPECIFIED DIAMETER mm		TOLERANCE—mm plus and minus Except as noted			
		ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER			
over	thru	Drawn Wire	Cold Finished Rod	Rolled Rod	
				Plus	Minus
..	0.80	0.015	..	..	..
0.80	1.60	0.025	..	..	..
1.60	10.00	0.040	..	..	..
10.00	12.50	..	0.040	0.50	0.50
12.50	25.00	..	0.050	0.63	0.63
25.00	40.00	..	0.06	..	..
40.00	50.00	..	0.10	..	..
50.00	70.00	..	0.15	..	..
70.00	90.00	..	0.20	..	..
90.00	120.00	..	0.30	..	..
120.00	150.00	..	0.50	..	..
150.00	175.00	..	0.63	..	..
175.00	200.00	..	0.80	..	..

TABLE 10.6 Diameter—Centerless Ground Round Wire and Rod

SPECIFIED DIAMETER mm		TOLERANCE mm plus and minus
		ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER
over	thru	
3.20	16.00	0.015
16.00	40.00	0.025
40.00	50.00	0.06

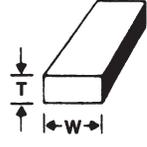
TABLE 10.7 Diameter—Rivet and Cold Heading Wire and Rod

SPECIFIED DIAMETER mm		TOLERANCE			
		ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER			
over	thru	Rivet Wire		Rivet Rod	
		mm plus	mm minus	mm plus	mm minus
..	1.60	0.015	0.015	..	..
1.60	3.20	0.025	0.015	..	..
3.20	4.00	0.025	0.025	..	..
4.00	10.00	0.050	0.025	..	..
10.00	12.50	..	..	0.050	0.025
12.50	25.00	..	..	0.08	0.025

TABLE 10.8 Diameter—Drawing Stock

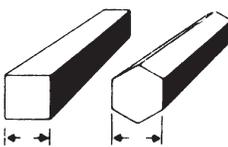
SPECIFIED DIAMETER mm		TOLERANCE—mm plus and minus
		ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER
Over	Thru	
10.00	12.50	0.50
12.50	25.00	0.63

TABLE 10.9 Thickness and Width—Rectangular Wire and Bar



SPECIFIED THICKNESS OR WIDTH mm		TOLERANCE mm plus and minus			
		ALLOWABLE DEVIATION FROM SPECIFIED THICKNESS AND WIDTH			
over	thru	Drawn Wire and Cold Finished Bar		Rolled Bar	
		Thickness	Width	Thickness	Width
..	0.80	0.025	..	..	..
0.80	1.60	0.040	..	..	..
1.60	12.50	0.050	0.050	0.15	..
12.50	20.00	0.06	0.06	0.20	0.40
20.00	25.00	0.06	0.06	0.30	0.40
25.00	40.00	0.08	0.08	0.40	0.40
40.00	50.00	0.13	0.13	0.40	0.80
50.00	70.00	0.20	0.20	0.50	0.80
70.00	100.00	..	0.25	0.50	0.80
100.00	160.00	..	..	..	1.20
160.00	250.00	..	..	..	1.60

TABLE 10.10 Distance across Flats—Square, Hexagonal and Octagonal Wire and Bar



SPECIFIED DISTANCE ACROSS FLATS mm		TOLERANCE mm plus and minus		
		ALLOWABLE DEVIATION FROM SPECIFIED DISTANCE ACROSS FLATS		
over	thru	Drawn Wire	Cold Finished Bar	Rolled Bar
		..	0.80	0.025
0.80	1.60	0.040	..	..
1.60	10.00	0.050	..	..
10.00	12.50	..	0.050	..
12.50	25.00	..	0.06	..
25.00	40.00	..	0.08	..
40.00	50.00	..	0.13	0.40
50.00	70.00	..	0.20	0.50
70.00	100.00	..	..	0.50

TABLE 10.11 Thickness and Width—Flattened Wire (Round Edge)

SPECIFIED THICKNESS mm		TOLERANCE mm plus and minus	SPECIFIED WIDTH mm		TOLERANCE mm plus and minus
over	thru		over	thru	
..	0.50	0.025	..	25.00	0.18
0.50	1.60	0.040	25.00	50.00	0.25
1.60	5.00	0.050	..	..	..

TABLE 10.12 Thickness and Width—Flattened and Slit Wire

SPECIFIED THICKNESS mm		TOLERANCE mm plus and minus	SPECIFIED WIDTH mm		TOLERANCE mm plus and minus
over	thru		over	thru	
0.40	0.50	0.025	12.50	16.00	0.06
0.50	1.60	0.040	16.00	40.00	0.10
1.60	2.00	0.050	40.00	120.00	0.15

TABLE 10.13 Length—Specific and Multiple—Rolled or Cold Finished Wire, Rod, and Bar

SPECIFIED DIAMETER, WIDTH OR DISTANCE ACROSS FLATS mm		TOLERANCE ⑤—mm plus ALLOWABLE DEVIATION FROM SPECIFIED LENGTH			
over	thru	Thru 5 000	over 5 000 thru 10 000	over 10 000 thru 15 000	over 15 000
..	70.00	4	7	10	25
70.00	200.00	6	9	11	25
200.00	..	7	10	13	25

TABLE 10.14 Twist ④—Bar and Straight Lengths

PRODUCT	TEMPER	SPECIFIED WIDTH: (RECTANGLES); SPECIFIED DISTANCE ACROSS FLATS: (SQUARES, HEXAGONS AND OCTAGONS) mm		TOLERANCE ① ③—DEGREES
		over	thru	ALLOWABLE DEVIATION FROM STRAIGHT
Square, Rectangular and Octagonal Bar	All except O and TX51 ②	.. 40.00 80.00	40.00 80.00 ..	3°/m but not greater than 7° 1.5°/m but not greater than 5° 1°/m but not greater than 3°
	TX51 ②	12.50 80.00	80.00 ..	4°/m but not greater than 7° 1°/m but not greater than 5°
Hexagonal Bar	All except O	.. 40.00 80.00	40.00 80.00 ..	3°/m but not greater than 7° 1.5°/m but not greater than 5° 1°/m but not greater than 3°

① For TX51 tempers, tolerance is applicable only to thicknesses of 12.50 mm and over.
 ② TX51 is a general designation for the following stress-relieved tempers: T351, T451, T651, T851, and T7351.
 ③ When weight of piece on flat surface minimizes deviation.
 ④ Twist is normally measured by placing the product on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the section and the flat surface. From this measurement, the actual deviation from straightness of the section at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are used to convert angular tolerance to linear deviation:

Tolerance Degrees	Max. Allowable Linear Deviation mm/mm of Width
0.25	0.004
0.5	0.009
1	0.017
1.5	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

⑤ For wire, rod and bar ordered as standard screw machine stock, the length tolerance is plus 10 mm.

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TABLE 10.15 Straightness—Rod and Bar in Straight Lengths Other than Screw Machine Stock

PRODUCT	TEMPER	SPECIFIED DIAMETER: (ROD); SPECIFIED DISTANCE ACROSS FLATS: (SQUARES, HEXAGONS AND OCTAGONS); SPECIFIED THICKNESS: (RECTANGLES) mm	TOLERANCE ①—mm ALLOWABLE DEVIATION FROM STRAIGHT, D(MAX)M,  IN TOTAL LENGTH OR IN ANY 300 MM OR LONGER CHORD SEGMENT OF TOTAL LENGTH.
ROLLED			
Rod and Hexagonal, Square, Rectangular and Octagonal Bar	All except O	All	4mm/m
COLD FINISHED			
Rod and Hexagonal Bar	All except O and TX51 ②	All	2mm/m
	TX51 ②	12.50 and over	2mm/m
Square, Rectangular and Octagonal Bar	All except O and TX51 ②	All	2mm/m
	TX51 ②	12.50 and over	4mm/m

TABLE 10.16 Straightness—Screw Machine Stock

SPECIFIED DIAMETER: (ROD); SPECIFIED DISTANCE ACROSS FLATS: (HEXAGONAL BAR) mm	TEMPER	TOLERANCE ① ALLOWABLE DEVIATION FROM STRAIGHT	
		In any 300 mm of length	In any standard length
All	All Except TX51 ②	0.3 mm	2.5 mm
12.50 and over	TX51 ②	0.3 mm	2.5 mm

TABLE 10.18 Angularity

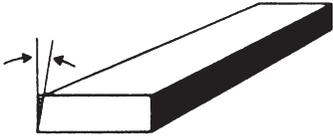

Allowable deviation from nominal angle: ±1 degree

TABLE 10.17 Flatness—Flat Surfaces

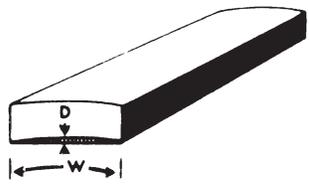
SURFACE WIDTH mm	TOLERANCE—mm 
	Maximum Allowable Deviation D
Up thru 25	0.10
Over 25	.004 · W (mm)
In any 25 mm of width	0.10

TABLE 10.19 Squareness of Saw Cuts

Allowable deviation from square: 1 degree

TABLE 10.20 Corner Radii Bar

Thickness, inches		Corner Radii mm, max.
over	thru	
1.90	10.00	0.4
10.00	40.00	0.8
40.00	..	1.2

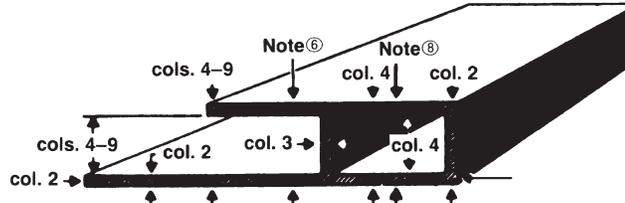
① When mass of piece on flat surface minimizes deviation.
② TX51 is a general designation for the following stress-relieved tempers: T351, T451, T851, and T7351.

11. Wire, Rod, Bar, and Profiles—Extruded

Table 11.1 intentionally blank

TABLE 11.2 Cross-Sectional Dimension Tolerances—Profiles ①

EXCEPT FOR T3510, T4510, T6510, T73510, T76510 AND T8510 TEMPER ⑦



SPECIFIED DIMENSION		TOLERANCE ② ③—mm plus and minus																		
		METAL DIMENSIONS				SPACE DIMENSIONS														
		ALLOWABLE DEVIATION FROM SPECIFIED DIMENSION WHERE 75 PERCENT OR MORE OF THE DIMENSION IS METAL ⑨ ⑩				ALLOWABLE DEVIATION FROM SPECIFIED DIMENSION WHERE MORE THAN 25 PERCENT OF THE DIMENSION IS SPACE ⑥ ⑧														
mm		All Except Those Covered by Column 3		Wall Thickness ④ Completely ⑤ Enclosing Space 70 mm ② and Over (Eccentricity)		At Dimensioned Points over 5 thru 15 mm from Base of Leg		At Dimensioned Points over 15 thru 30 mm from Base of Leg		At Dimensioned Points over 30 thru 60 mm from Base of Leg		At Dimensioned Points over 60 thru 100 mm from Base of Leg		At Dimensioned Points over 100 thru 150 mm from Base of Leg		At Dimensioned Points over 150 thru 200 mm from Base of Leg				
Col. 1		Col. 2		Col. 3		Col. 4		Col. 5		Col. 6		Col. 7		Col. 8		Col. 9				
over	thru	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ⑪	Precision Tolerance, All Except 5XXX Alloys			
CIRCUMSCRIBING CIRCLE SIZES THRU 250 mm IN DIAMETER																				
..	3.20	0.15	0.10	±10% of specified dimension; ±1.50 max. ±.25 min.	±10% of specified dimension; ±1.50 max. ±.25 min.	0.25	0.17	0.30	0.20	..	..	..	..	..	..	..	..
3.20	6.30	0.18	0.12			0.30	0.20	0.36	0.24	0.41	0.27	0.41	0.27	0.50	0.33	..	..	..
6.30	12.50	0.20	0.13			0.36	0.24	0.41	0.27	0.46	0.30	0.50	0.33	0.56	0.37	..	..	..
12.50	20.00	0.23	0.15			0.41	0.27	0.46	0.30	0.50	0.33	0.56	0.37	0.64	0.42	0.76	0.50	..		
20.00	25.00	0.25	0.17			0.46	0.30	0.50	0.33	0.56	0.37	0.64	0.42	0.76	0.50	0.76	0.50	..		
25.00	40.00	0.30	0.20	±15% of specified dimension; ±2.30 max. ±.38 min.	±15% of specified dimension; ±2.30 max. ±.38 min.	0.54	0.36	0.58	0.38	0.66	0.44	0.76	0.50	0.88	0.58	..	..	
40.00	50.00	0.36	0.24			0.60	0.40	0.66	0.44	0.78	0.51	0.92	0.61	1.05	0.69	1.25	0.83	..		
50.00	100.00	0.60	0.40			0.86	0.57	0.96	0.63	1.20	0.79	1.45	0.96	1.70	1.12	2.05	1.35	..		
100.00	150.00	0.86	0.57			1.10	0.73	1.25	0.83	1.65	1.09	2.00	1.32	2.40	1.58	2.80	1.85	..		
150.00	200.00	1.10	0.73			1.35	0.89	1.55	1.02	2.10	1.39	2.50	1.65	3.05	2.01	3.55	2.34	..		
200.00	250.00	1.35	0.89			1.65	1.09	1.90	1.25	2.50	1.65	3.05	2.01	3.70	2.44	4.30	2.84	..		
25.00	40.00	0.48	0.32			±15% of specified dimension; ±2.30 max. ±.38 min.	±15% of specified dimension; ±2.30 max. ±.38 min.	0.46	0.30	0.50	0.33	
40.00	50.00	0.60	0.40					0.48	0.32	0.56	0.37	0.72	0.48
50.00	100.00	0.86	0.57					0.50	0.33	0.60	0.40	0.76	0.50	1.25	0.83
100.00	150.00	1.10	0.73					0.56	0.37	0.68	0.45	1.00	0.66	1.50	0.99
150.00	200.00	1.35	0.89	0.58	0.38			0.76	0.50	1.25	0.83	1.80	1.19	2.30	1.52	..	..	..
200.00	250.00	1.65	1.09	0.60	0.40			0.86	0.57	1.50	0.99	2.05	1.35	2.55	1.68	..	..	..
250.00	300.00	1.90	1.25	0.86	0.57			1.10	0.73	1.80	1.19	2.30	1.52	2.80	1.85	4.30	2.84	..		
300.00	350.00	2.15	1.42	1.10	0.73			1.35	0.89	2.05	1.35	2.55	1.68	3.05	2.01	4.55	3.00	..		
350.00	400.00	2.40	1.58	1.35	0.89			1.65	1.09	2.30	1.52	2.80	1.85	3.30	2.18	4.85	3.20	..		
400.00	450.00	2.65	1.75	1.65	1.09			1.90	1.25	2.55	1.68	3.05	2.01	3.55	2.34	5.10	3.37	..		
450.00	500.00	2.90	1.91	1.90	1.25	2.15	1.42	2.80	1.85	3.30	2.18	3.80	2.51	5.35	3.53	..				
500.00	550.00	3.15	2.08	2.15	1.42	2.40	1.58	3.05	2.01	3.55	2.34	4.05	2.67	5.60	3.70	..				
550.00	600.00	3.40	2.24	2.40	1.58	2.65	1.75	3.30	2.18	3.80	2.51	4.30	2.84	5.85	3.86	..				
600.00	..	3.65	2.41	2.65	1.75	2.90	1.91	3.55	2.34	4.05	2.67	4.55	3.00	6.10	4.03	..				
..	..	3.90	2.57	2.90	1.91	3.15	2.08	3.80	2.51	4.30	2.84	4.85	3.20	6.35	4.19	..				
..	..	4.05	2.67	3.15	2.08	3.40	2.24	4.05	2.67	4.55	3.00	5.10	3.37	6.60	4.36	..				
..	..	4.30	2.84	3.40	2.24	3.65	2.41	4.30	2.84	4.85	3.20	5.35	3.53	6.85	4.52	..				
..	..	4.55	3.00	3.65	2.41	3.90	2.57	4.55	3.00	5.10	3.37	5.60	3.70	7.10	4.69	..				

Footnotes for Tables 11.2 through 11.4

① These Standard and Precision Tolerances are applicable to the average profile. The extrusion conditions required to produce the wide variety of alloy-temper and profile combinations require close review between customer and producer to determine critical characteristics and tolerance capability. Aggressive profile characteristics may require wider than standard tolerance and closer than precision tolerance may be feasible for other characteristics.

② The tolerance applicable to a dimension composed of two or more component dimensions is the sum of the tolerances of the component dimensions if all of the component dimensions are indicated.

③ When a dimension tolerance is specified other than as an equal bilateral tolerance, the value of the standard tolerance is that which applies to the mean of the maximum and minimum dimensions permissible under the tolerance for the dimension under consideration.

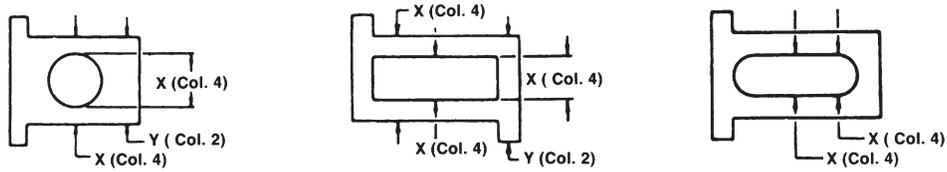
④ Where dimensions specified are outside and inside, rather than wall thickness itself, the allowable deviation (eccentricity) given in Column 3 applies to mean wall thickness. (Mean wall thickness is the average of two wall thickness measurements taken at opposite sides of the void.)

(Continued on bottom of next page)

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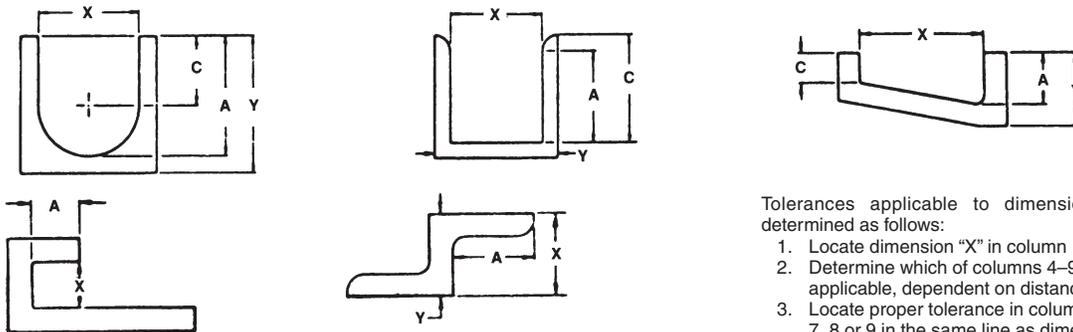
Examples Illustrating Use of Table 11.2, Page 11-6

Closed-Space Dimensions



All dimensions designated "Y" are classed as "metal dimensions," and tolerances are determined from column 2.
 Dimensions designated "X" are classed as "space dimensions through an enclosed void," and the tolerances applicable are determined from column 4 unless 75 percent or more of the dimension is metal, in which case column 2 applies.

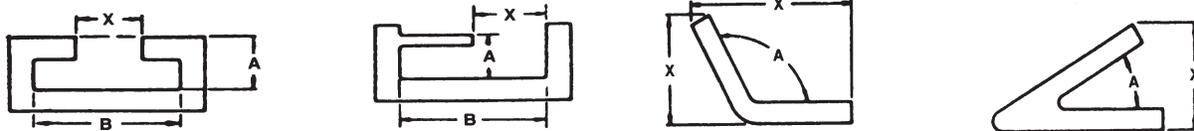
Open-Space Dimensions



Dimensions "Y" are "metal dimensions"; tolerances are determined from column 2.
 Distances "C" are shown merely to indicate incorrect values for determining which of columns 4-9 apply.

Tolerances applicable to dimensions "X" are determined as follows:

1. Locate dimension "X" in column 1.
2. Determine which of columns 4-9 is applicable, dependent on distance "A."
3. Locate proper tolerance in column 4, 5, 6, 7, 8 or 9 in the same line as dimension "X."



Tolerances applicable to dimensions "X" are determined as follows:

1. Locate distance "B" in column 1.
2. Determine which of columns 4-9 is applicable, dependent on distance "A."
3. Locate proper tolerance in column 4, 5, 6, 7, 8 or 9 in the same line as value chosen in column 1.

Tolerances applicable to dimensions "X" are not determined from Table 11.2; tolerances are determined by standard tolerances applicable to angles "A."

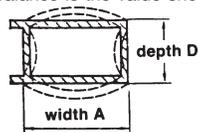
Footnotes for Tables 11.2 through 11.4 (Continued)

⑤ In the case of Class 1 Hollow Profiles the standard wall thickness tolerance for extruded round tube is applicable. (A Class 1 Hollow Profile is one whose void is round and one inch or more in diameter and whose weight is equally distributed on opposite sides of two or more equally spaced axes.)

⑥ At points 5 mm and less from base of leg the tolerances in Col. 2 are applicable.

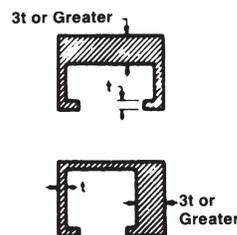
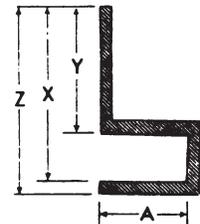
⑦ Tolerances for extruded profiles in T3510, T4510, T6510, T73510, T76510 and T8510 tempers shall be as agreed upon between purchaser and vendor at the time the contract or order is entered.

⑧ The following tolerances apply where the space is completely enclosed (hollow profiles); For the width (A), the balance is the value shown in Col. 4 for the depth dimension (D). For the depth (D), the tolerance is the value shown in Col. 4 for the width dimension (A). In no case is the tolerance for either width or depth less than the metal dimensions (Col. 2) at the corners.



Example—Alloy 6061 hollow profile having 25 · 75 mm rectangular outside dimensions; width tolerance is ±0.46 mm and depth tolerance ±0.86 mm. (Tolerances at corners, Col. 2, metal dimensions, are ±0.60 mm for the width and ±0.25 mm for the depth.) Note that the Col. 4 tolerance of 0.46 mm must be adjusted to 0.60 mm so that it is not less than the Col. 2 tolerance.

⑨ These tolerances do not apply to space dimensions such as dimensions "X" and "Z" of the example (right), even when "Y" is 75 percent or more of "X." For the tolerance applicable to dimensions "X" and "Z," use Col. 4, 5, 6, 7, 8 or 9, dependent on distance "A."



⑩ The wall thickness tolerance for hollow or semihollow profiles shall be as agreed upon between purchaser and vendor at the time the contract or order is entered when the nominal thickness of one wall is three times or greater than that of the opposite wall.

⑪ 5xxx alloys tolerances are 150% of all other alloys, standard tolerance.

TABLE 11.3 Diameter or Distance Across Flats—Round Wire and Rod - Square, Hexagonal and Octagonal Wire and Bar^①

SPECIFIED DIMENSION mm		TOLERANCE ^③ —mm plus and minus							
		ALLOWABLE DEVIATION FROM SPECIFIED DIMENSION ACROSS FLATS OR DIAMETER							
		ROUND WIRE AND ROD		SQUARE WIRE AND BAR		HEXAGONAL WIRE AND BAR		OCTAGONAL WIRE AND BAR	
over	thru	Standard Tolerance, All Except 5XXX Alloys ^①	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ^①	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ^①	Precision Tolerance, All Except 5XXX Alloys	Standard Tolerance, All Except 5XXX Alloys ^①	Precision Tolerance, All Except 5XXX Alloys
..	3.20	0.15	0.10	0.15	0.10	0.15	0.10	0.15	0.10
3.20	6.30	0.18	0.12	0.18	0.12	0.18	0.12	0.18	0.12
6.30	12.50	0.20	0.13	0.20	0.13	0.20	0.13	0.20	0.13
12.50	19.00	0.23	0.15	0.23	0.15	0.23	0.15	0.23	0.15
19.00	25.00	0.25	0.17	0.25	0.17	0.25	0.17	0.25	0.17
25.00	40.00	0.30	0.20	0.30	0.20	0.30	0.20	0.30	0.20
40.00	50.00	0.36	0.24	0.36	0.24	0.36	0.24	0.36	0.24
50.00	100.00	0.61	0.40	0.61	0.40	0.61	0.40	0.61	0.40
100.00	150.00	0.86	0.57	0.86	0.57	0.86	0.57	0.86	0.57
150.00	180.00	1.10	0.73	1.10	0.73	1.10	0.73	1.10	0.73
180.00	200.00	1.10	0.73	1.35	0.89	1.10	0.73	1.10	0.73
200.00	220.00	1.35	0.89	1.65	1.09	1.35	0.89	1.35	0.89
220.00	235.00	1.35	0.89	1.65	1.09	1.65	1.09	1.35	0.89
235.00	250.00	1.35	0.89	1.65	1.09	1.65	1.09	1.65	1.09
250.00	300.00	1.90	1.25	1.90	1.25	1.90	1.25	1.90	1.25
300.00	350.00	2.15	1.42	2.15	1.42	2.15	1.42	2.15	1.42
350.00	400.00	2.40	1.58	2.40	1.58	2.40	1.58	2.40	1.58

Note: Shaded tolerances denote products with a circumscribing circle size of 250 inches in diameter.

For all numbered footnotes, see two preceding pages.

TABLE 11.4 Thickness or Width (Distance Across Flats)—Rectangular Wire and Bar^①

SPECIFIED DIMENSION mm		TOLERANCE—mm plus and minus			
		ALLOWABLE DEVIATION FROM SPECIFIED WIDTH OR THICKNESS ACROSS FLATS			
		Standard Tolerance, All Except, 5XXX Alloys ^①	Precision Tolerance, All Except, 5XXX Alloys	Standard Tolerance, All Except, 5XXX Alloys ^①	Precision Tolerance, All Except, 5XXX Alloys
over	thru				
..	3.20	0.15	0.10	0.36	0.24
3.20	6.30	0.18	0.12	0.38	0.25
6.30	12.50	0.20	0.13	0.41	0.27
12.50	20.00	0.23	0.15	0.43	0.28
20.00	25.00	0.25	0.17	0.46	0.30
25.00	40.00	0.30	0.20	0.48	0.32
40.00	50.00	0.36	0.24	0.61	0.40
50.00	100.00	0.61	0.40	0.86	0.57
100.00	150.00	0.86	0.57	1.10	0.73
150.00	200.00	1.10	0.73	1.35	0.89
200.00	250.00	1.35	0.89	1.60	1.06
250.00	300.00	..	..	1.90	1.25
300.00	350.00	..	..	2.15	1.42
350.00	400.00	..	..	2.40	1.58
400.00	450.00	..	..	2.65	1.75
450.00	500.00	..	..	2.90	1.91
500.00	550.00	..	..	3.15	2.08
550.00	600.00	..	..	3.40	2.24

Note: Shaded tolerances denote products with a circumscribing circle size over 250 mm in diameter.

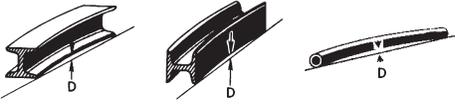
For all numbered footnotes, see two preceding pages.

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TABLE 11.5 Length ①—Wire, Rod, Bar and Profiles

SPECIFIED DIAMETER (WIRE AND ROD): SPECIFIED WIDTH (BAR): CIRCUMSCRIBING CIRCLE DIAMETER ④ (PROFILES): mm		TOLERANCE—mm plus			
		ALLOWABLE DEVIATION FROM SPECIFIED LENGTH			
		SPECIFIED LENGTH—mm			
over	thru	Up thru 5 000	Over 5 000 thru 10 000	Over 10 000 thru 15 000	Over 15 000
..	70.00	4	7	10	25
70.00	200.00	6	9	11	25
200.00	..	7	10	13	25

TABLE 11.6 Straightness ①—Rod, Bar and Profiles

PRODUCT	TEMPER	SPECIFIED DIAMETER (ROD): SPECIFIED WIDTH (BAR): CIRCUMSCRIBING CIRCLE DIAMETER ④ (PROFILES): mm		SPECIFIED THICKNESS (RECTANGLES): MINIMUM THICKNESS (PROFILES): mm		TOLERANCE ③—mm
		over	thru	over	thru	ALLOWABLE DEVIATION (D) FROM STRAIGHT ④
						
Rod and Square, Hexagonal and Octagonal Bar	All except O, TX510 ②, TX511 ②	All		..	..	1 mm/m
	O	12.50	..	..	..	4 mm/m
	TX510 ②	12.50	..	..	..	4 mm/m
	TX511 ②	12.50	..	..	..	1 mm/m
Rectangular Bar	All except O, TX510 ②, TX511 ②	..	40.00	..	2.50	4 mm/m
		40.00	..	All	..	1 mm/m
	O	12.50	..	..	..	4 mm/m
	TX510 ②	12.50	..	12.50	..	4 mm/m
	TX511 ②	12.50	..	12.50	..	1 mm/m
Profiles	All except O, TX510 ② ⑤, TX511 ②	..	40.00	..	2.50 ⑦	4 mm/m
		40.00	..	2.50	..	1 mm/m
	O	12.50	..	..	2.50 ⑦	16 mm/m
	..	..	2.50	..	..	4 mm/m
	TX511 ②	12.50	..	..	2.50 ⑦	4 mm/m
..	..	2.50	..	..	1 mm/m	

Footnotes for Tables 11.5 through 11.8

- ① These Standard Tolerances are applicable to the average profile; wider tolerances may be required for some profiles, and closer tolerances may be possible for others.
- ② TX510 and TX511 are general designations for the following stress relieved tempers: T3510, T4510, T61510, T6510, T8510, T73510, T76510 and T3511, T4511, T61511, T6511, T8511, T73511, T76511, respectively.
- ③ When weight of piece on the flat surface minimizes deviation.
- ④ The circumscribing circle diameter is the diameter of the smallest circle that will completely enclose the cross section of the extruded product.
- ⑤ Tolerances for T3510, T4510, T6510, T73510, T76510, and T8510 tempers shall be as agreed upon between purchaser and vendor at the time the contract or order is entered.
- ⑥ Twist is normally measured by placing the product on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the section and the flat surface. From this measurement, the actual deviation from straightness of the section at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are used to convert angular tolerance to linear deviation:

Tolerance Degrees	Max. Allowable Linear Deviation mm/mm of Width
0.25	0.004
0.5	0.009
1	0.017
1.5	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

- ⑦ Applies only if the thickness along at least 1/3 of the total perimeter is 2.50 mm or less. Otherwise use the tolerance shown for 2.50 mm and over.
- ⑧ Tolerance for "O" temper material is four times the standard tolerances shown.
- ⑨ Straightness must be met in all orientations, including orientations which are not self supporting.

TABLE 11.7 Twist ① ⑥—Bar and Profiles

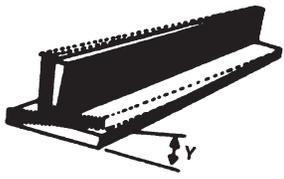
PRODUCT	TEMPER	SPECIFIED WIDTH (BAR):		SPECIFIED THICKNESS (RECTANGLES):		TOLERANCE ③—Degrees	
		CIRCUMSCRIBING CIRCLE DIAMETER ④ (PROFILES):		MINIMUM THICKNESS (PROFILES):			
		over	thru	over	thru	 Allowable deviation from straight, y(max), in total length or in any 300 mm chord segment of the total length	
Bar	All except O TX510 ②, TX511 ②	.. 40.00 80.00	40.00 80.00 ..	All All All			3°/m but not greater than 7° 1.5°/m but not greater than 5° 1°/m but not greater than 3°
	O	12.50 40.00 80.00	40.00 80.00 ..	12.50 12.50 12.50	.. .. ..	9°/m but not greater than 21° 4.5°/m but not greater than 15° 3°/m but not greater than 9°
	TX510 ②	12.50 80.00	80.00 ..	12.50 12.50	.. ..	4°/m but not greater than 7° 1.5°/m but not greater than 5°
	TX511 ②	12.50 40.00 80.00	40.00 80.00 ..	12.50 12.50 12.50	.. .. ..	3°/m but not greater than 7° 1.5°/m but not greater than 5° 1°/m but not greater than 3°
Profiles	All except O TX510 ② ⑤ TX511 ②	.. 40.00 80.00	40.00 80.00 ..	All All All		3°/m but not greater than 7° 1.5°/m but not greater than 5° 1°/m but not greater than 3°	
	O	12.50 12.50 40.00 80.00	.. 40.00 80.00 ..	.. 2.50 2.50 2.50	2.50	9°/m but not greater than 21° 9°/m but not greater than 21° 4.5°/m but not greater than 15° 3°/m but not greater than 9°
	TX511 ②	12.50 12.50	.. 40.00	.. 2.50	2.50 2.50	2.50 2.50	3°/m but not greater than 7° 3°/m but not greater than 7°
		40.00 80.00	80.00 ..	2.50 2.50	2.50 ..	2.50 ..	1.5°/m but not greater than 5° 1°/m but not greater than 3°

TABLE 11.8 Flatness (Flat Surfaces) ①—Bar, Solid Profiles and Semihollow Profiles

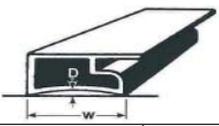
EXCEPT FOR PROFILES IN O ⑧ T3510, T4510, T6510, T73510, T76510 and T8510 TEMPER ⑤

MINIMUM THICKNESS OF METAL FORMING THE SURFACE mm		SURFACE WIDTH—mm										
		UP THRU 150.00	OVER 150.00 THRU 200.00	OVER 200.00 THRU 250.00	OVER 250.00 THRU 300.00	OVER 300.00 THRU 350.00	OVER 350.00 THRU 400.00	OVER 400.00 THRU 450.00	OVER 450.00 THRU 500.00	OVER 500.00 THRU 550.00	OVER 550.00 THRU 600.00	OVER 600
OVER	THRU	TOLERANCE FACTOR										
Up thru	3.20	0.004	0.006	0.10	0.14	..	..	..	..	..	..	..
3.20	4.00	0.004	0.006	0.008	0.013	0.014	0.014	0.014	..	..	..	..
4.00	5.00	0.004	0.006	0.007	0.012	0.013	0.013	0.013	..	..	..	..
5.00	6.30	0.004	0.006	0.006	0.010	0.012	0.012	0.012	0.014	0.014	..	..
6.30	8.00	0.004	0.006	0.006	0.008	0.010	0.010	0.012	0.012	0.012	0.014	..
8.00	12.50	0.004	0.004	0.006	0.008	0.008	0.008	0.010	0.010	0.010	0.012	0.012
12.50	20.00	0.004	0.004	0.006	0.006	0.008	0.008	0.008	0.008	0.008	0.010	0.012
20.00	25.00	0.004	0.004	0.006	0.006	0.008	0.008	0.008	0.008	0.008	0.008	0.010
25.00	40.00	0.004	0.004	0.004	0.006	0.006	0.008	0.008	0.008	0.008	0.008	0.008
40.00	50.00	0.004	0.004	0.004	0.004	0.006	0.006	0.006	0.008	0.008	0.008	0.008
50.00	..	0.004	0.004	0.004	0.004	0.004	0.006	0.006	0.006	0.008	0.008	0.008

For all numbered footnotes, see page 27.

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TABLE 11.9 Flatness (Flat Surfaces) ① —Hollow Profiles (EXCEPT FOR PROFILES IN O ⑩, T3510, T4510, T6510, T73510, T76510 and T8510 TEMPER^④)

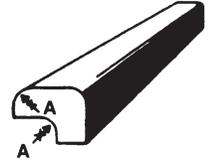


MINIMUM THICKNESS OF METAL FORMING THE SURFACE mm		SURFACE WIDTHS UP THRU 25 mm OR ANY 25 mm INCREMENT OF WIDER SURFACES Maximum Allowable Deviation D = TOLERANCE FACTOR x 25 (mm)										
		WIDTHS OVER 25 mm Maximum Allowable Deviation D = TOLERANCE x W (mm)										
		SURFACE WIDTH—mm										
OVER	THRU	UP THRU 150.00	OVER 150.00 THRU 200.00	OVER 200.00 THRU 250.00	OVER 250.00 THRU 300.00	OVER 300.00 THRU 350.00	OVER 350.00 THRU 400.00	OVER 400.00 THRU 450.00	OVER 450.00 THRU 500.00	OVER 500.00 THRU 550.00	OVER 550.00 THRU 600.00	OVER 600
		TOLERANCE FACTOR										
Up thru	3.20	0.006	0.008	0.012	0.016	..	..	..	..	..	..	..
3.20	4.00	0.006	0.008	0.010	0.014	0.016	..	..	..	..	..	..
4.00	5.00	0.005	0.007	0.010	0.013	0.015	0.015	..	..	..	..	..
5.00	6.30	0.004	0.006	0.010	0.012	0.014	0.014	0.014	0.016	..	..	..
6.30	8.50	0.004	0.006	0.008	0.010	0.012	0.012	0.012	0.014	0.014	0.016	..
8.00	12.50	0.004	0.006	0.008	0.010	0.010	0.010	0.012	0.012	0.012	0.014	0.016
12.50	20.00	0.004	0.004	0.006	0.008	0.008	0.008	0.010	0.010	0.012	0.012	0.014
20.00	25.00	0.004	0.004	0.006	0.006	0.008	0.008	0.008	0.008	0.010	0.10	0.012
25.00	40.00	0.004	0.004	0.004	0.006	0.006	0.008	0.008	0.008	0.008	0.008	0.008

TABLE 11.10 Surface Roughness ① ⑧— Extruded Wire, Rod, Bar and Profiles

SPECIFIED SECTION THICKNESS mm		ALLOWABLE DEPTH OF CONDITIONS ② mm max.
over	thru	
..	1.60	0.040
1.60	3.20	0.050
3.20	5.00	0.06
5.00	6.30	0.08
6.30	12.50	0.10
12.50	..	0.20

TABLE 11.13 Corner and Fillet Radii ①— Extruded Bar and Profiles



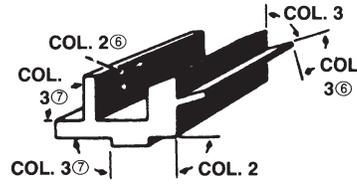
SPECIFIED RADIUS ⑨ mm		TOLERANCE—mm
		ALLOWABLE DEVIATION FROM SPECIFIED RADIUS
over	thru	Difference between radius A and specified radius
Sharp Corners	5.00	±0.5 (1 mm if unspecified)
..	..	±0.5
5.00	..	±10%

TABLE 11.11 Contour (Curved Surfaces) ① ③— Extruded Profiles



Temper	
All except O, TX510 ④	Allowable deviation from specified contour: 0.005 mm per mm of chord length (C); 0.13 mm minimum. Not applicable to contours with chord length over 150 mm.
O	Allowable deviation from specified contour: 0.015 mm per mm of chord length (C); 0.40 mm minimum. Not applicable to contours with chord length over 150 mm.

TABLE 11.14 Angularity ① ⑤—Extruded Bar and Profiles



TEMPER		SPECIFIED THICKNESS OF THINNER LEG mm		TOLERANCE Degrees plus and minus	
				ALLOWABLE DEVIATION FROM SPECIFIED ANGLE	
		RATIO: ⑥ ⑦ LEG OR SURFACE LENGTH TO LEG OR METAL THICKNESS			
over	thru	1 and less	Over 1 thru 40		
		Col. 1	Col. 2	Col. 3	
All except O, TX510 ④	..	5.00	1	2	
	5.00	20.00	1	1.5	
	20.00	..	1	1	
O	..	5.00	3	6	
	5.00	20.00	3	4.5	
	20.00	..	3	3	

TABLE 11.12 Squareness of Cut Ends ①— Extruded Rod, Bar and Profiles

Allowable deviation from square: 1 degree

For all numbered footnotes, see page 30.

Footnotes for Tables 11.9 through 11.14

- ① These Standard Tolerances are applicable to the average profile; wider tolerances may be required for some profiles, and closer tolerances may be possible for others.
- ② Conditions include die lines and handling marks.
- ③ As measured with a contour gage whose surface is limited to a maximum subtended angle of 90 degrees. Extruded curved surfaces comprising more than a 90-degree subtended angle are checked by sliding the gage across the surface, thus checking two or more 90-degree portions of the surface. Extruded profile surfaces comprising arcs formed by two or more radii require the use of a separate contour gage for each portion of the surface formed by an individual radius.
- ④ Tolerances for T3510, T4510, T6510, T73510, T76510 and T8510 tempers shall be as agreed upon between the purchaser and vendor and at the time the contract or order is entered.

- ⑤ Angles are measured with protractors or with gages. As illustrated, a four-point contact system is used, two contact points being as close to the angle vertex as practical, and the others near the ends of the respective surfaces forming the angle. Between these points of measurement surface flatness is the controlling tolerance.



- ⑥ When the area between the surface forming an angle is all metal, values in column 2 apply if the larger surface length to metal thickness ratio is 1 or less.
- ⑦ When two legs are involved the one having the larger ratio determines the applicable column.
- ⑧ Not applicable to 2219 alloy extrusions. Most profiles in 2219 alloy will have die lines about twice the depth shown in the table; however, for each profile the supplier should be contacted for the roughness value to apply.
- ⑨ If unspecified, the radius shall be 1 mm maximum including tolerances.
- ⑩ Tolerance for "O" temper material is four times the standard tolerances shown.

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12. Tube and Pipe

Table 12.1 intentionally blank

TABLE 12.2 Diameter—Round Tube

EXCEPT FOR T3510, T4510, T6510, T73510 AND T8510 TEMPER^⑦

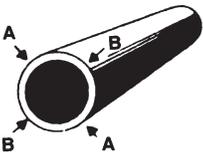
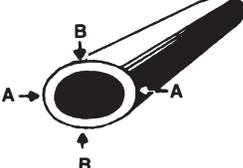
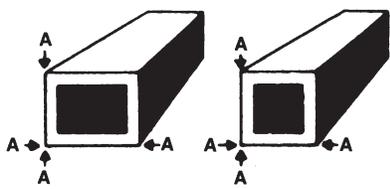
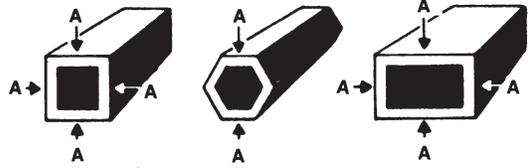
SPECIFIED DIAMETER ^① mm		TOLERANCE ^② —mm plus and minus			
		ALLOWABLE DEVIATION OF MEAN DIAMETER ^③ FROM SPECIFIED DIAMETER (Size)		ALLOWABLE DEVIATION OF DIAMETER AT ANY POINT FROM SPECIFIED DIAMETER ^④	
		 <p>Difference between $\frac{1}{2}(AA+BB)$ and specified diameter</p>		 <p>Difference between AA or BB and specified diameter</p>	
Col. 1		Col. 2		Col. 3	
over	thru	5xxx4.0 nominal Mg ^⑩	Other Alloys	5xxx4.0 nominal Mg ^⑩	Other Alloys
12.50	25.00	0.38	0.25	0.76	0.50
25.00	50.00	0.46	0.30	0.96	0.64
50.00	100.00	0.58	0.38	1.15	0.76
100.00	150.00	0.96	0.64	1.90	1.25
150.00	200.00	1.35	0.88	2.85	1.90
200.00	250.00	1.75	1.15	3.80	2.55
250.00	300.00	2.10	1.40	4.80	3.20
300.00	350.00	2.50	1.65	5.70	3.80
350.00	400.00	2.85	1.90	6.70	4.45
400.00	450.00	3.25	2.15	7.60	5.10

TABLE 12.3 Width and Depth—Square, Rectangular, Hexagonal and Octagonal Tube

EXCEPT FOR T3510, T4510, T6510, T73510 AND T8510 TEMPER^⑦

SPECIFIED WIDTH OR DEPTH mm		TOLERANCE ^② —mm plus and minus				
		ALLOWABLE DEVIATION OF WIDTH OR DEPTH AT CORNERS FROM SPECIFIED WIDTH OR DEPTH		ALLOWABLE DEVIATION OF WIDTH OR DEPTH NOT AT CORNERS FROM SPECIFIED WIDTH OR DEPTH ^④		
		 <p>Difference between AA and specified width or depth</p>		 <p>Difference between AA and specified width, depth, or distance across flats</p>		
Col. 1		Col. 2		Col. 3		Col. 4
over	thru	5xxx4.0 nominal Mg ^⑩	Other Alloys	5xxx4.0 nominal Mg ^⑩	Other Alloys	All Alloys
12.50	20.00	0.46	0.30	0.76	0.50	The tolerance for the width is the value in the previous column for a dimension equal to the depth, and conversely, but in no case is the tolerance less than at the corners.
20.00	25.00	0.54	0.36	0.76	0.50	
25.00	50.00	0.68	0.46	0.96	0.64	
50.00	100.00	0.96	0.64	1.35	0.88	
100.00	130.00	1.35	0.88	1.75	1.15	
130.00	150.00	1.75	1.15	2.10	1.40	Example: The width tolerance of a 25 75 mm alloy 6061 rectangular tube is ±0.50 mm and the depth tolerance ±0.88 mm.
150.00	180.00	2.10	1.40	2.50	1.65	
180.00	200.00	2.50	1.65	2.75	1.90	
200.00	230.00	2.85	1.90	3.10	2.15	
230.00	250.00	3.25	2.15	3.65	2.40	
250.00	280.00	3.65	2.40	4.00	2.65	
280.00	330.00	4.00	2.65	4.40	2.90	

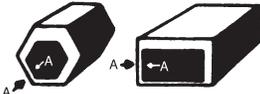
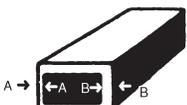
For all numbered footnotes, see page 35.

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TABLE 12.4 Wall Thickness—Round Extruded Tube

SPECIFIED WALL THICKNESS ⑥ mm		TOLERANCE ① ②—mm plus and minus									ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM MEAN WALL THICKNESS ⑤ (Eccentricity)  Difference between AA and mean wall thickness
		ALLOWABLE DEVIATION OF MEAN WALL THICKNESS ⑤ FROM SPECIFIED WALL THICKNESS  Difference between ½ (AA + BB) and specified wall thickness									
		OUTSIDE DIAMETER—mm									
		thru 30		over 30 thru 80		over 80 thru 130		over 130			
Col. 1		Col. 2		Col. 3		Col. 4		Col. 5		Col. 6	
over	thru	5xxx 4.0 nominal Mg ⑩	Other Alloys	5xxx 4.0 nominal Mg ⑩	Other Alloys	5xxx 4.0 nominal Mg ⑩	Other Alloys	5xxx 4.0 nominal Mg ⑩	Other Alloys	All Alloys	
..	1.20	0.23	0.15	Plus and minus 10% of mean wall thickness	
1.20	1.60	0.28	0.18	0.30	0.20	0.30	0.20	0.38	0.25		
1.60	2.00	0.30	0.20	0.30	0.20	0.36	0.23	0.46	0.35		
2.00	3.20	0.36	0.23	0.36	0.23	0.38	0.25	0.58	0.38		
3.20	6.30	0.36	0.23	0.36	0.23	0.50	0.33	0.76	0.50		
6.30	10.00	0.43	0.28	0.43	0.28	0.60	0.41	0.96	0.64		
10.00	12.50	0.58	0.38	0.80	0.54	1.35	0.88	max ±1.50 min ±0.25	
12.50	20.00	..	..	0.76	0.50	1.05	0.72	1.75	1.15
20.00	25.00	..	..	..	..	1.35	0.88	2.10	1.40
25.00	35.00	..	..	..	..	1.75	1.15	2.50	1.65
35.00	50.00	..	..	..	..	..	..	2.85	1.90
50.00	60.00	3.25	2.15	±3.00	
60.00	80.00	..	..	..	..	..	..	3.65	2.40
80.00	90.00	..	..	..	..	..	..	4.00	2.65
90.00	100.00	..	..	..	..	..	..	4.40	2.90

TABLE 12.5 Wall Thickness—Other—Than—Round Extruded Tube

SPECIFIED WALL THICKNESS ⑥ mm		TOLERANCE ① ②—mm plus and minus						ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM MEAN WALL THICKNESS ⑤ (Eccentricity)  Difference between AA and mean wall thickness
		ALLOWABLE DEVIATION OF MEAN WALL THICKNESS ⑤ FROM SPECIFIED WALL THICKNESS  Difference between ½ (AA + BB) and specified wall thickness						
		CIRCUMSCRIBING CIRCLE DIAMETER ⑩—mm						
		thru 130		over 130		thru 130			over 130
Col. 1		Col. 2		Col. 3		Col. 4		Col. 5
over	thru	5xxx4.0 nominal Mg ⑩	Other Alloys	5xxx4.0 nominal Mg ⑩	Other Alloys	All Alloys	All Alloys	All Alloys
..	1.20	0.20	0.13	0.30	0.20	0.13	0.13	Plus and minus 10% of mean wall thickness
1.20	1.60	0.23	0.15	0.36	0.23	0.18	0.18	
1.60	3.20	0.28	0.18	0.38	0.25	0.25	0.25	
3.20	6.30	0.30	0.20	0.58	0.38	0.38	0.38	
6.30	10.00	0.43	0.28	0.76	0.50	0.64	0.64	
10.00	12.50	0.52	0.36	1.15	0.76	0.76	0.76	
12.50	20.00	0.96	0.64	1.50	1.00	1.00	1.00	max ±1.50 min ±0.25
20.00	25.00	1.35	0.90	1.90	1.25	1.25	1.25	
25.00	35.00	1.75	1.15	2.30	1.50	1.50	1.50	
35.00	50.00	..	..	2.65	1.80	..	..

For all numbered footnotes, see page 35.

TABLE 12.6 Length—Extruded Tube

SPECIFIED OUTSIDE DIAMETER OR WIDTH mm		TOLERANCE—mm plus excepted as noted							
		ALLOWABLE DEVIATION FROM SPECIFIED LENGTH							
		STRAIGHT				COILED			
		SPECIFIED LENGTH—mm							
over	thru	Up thru 5 000	Over 5 000 thru 10 000	Over 10 000 thru 15 000	Over 15 000	Up thru 30 000	Over 30 000 thru 75 000	Over 75 000 thru 150 000	Over 150 000
12.50	35.00	4	7	10	25	+5%, -0%	±10%	±15%	±20%
35.00	70.00	4	7	10	25	..	..	..	..
70.00	200.00	6	9	11	25	..	..	..	..
200.00	..	7	10	13	25	..	..	..	..

TABLE 12.7 Twist ^⑪—Other-than-Round Extruded Tube

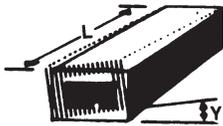
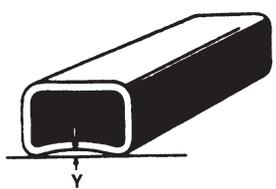
TEMPER	SPECIFIED WIDTH mm		SPECIFIED THICKNESS mm		TOLERANCE ^⑨ —Degrees
					 Y (max.) in degrees
over	thru	over	thru		
All except O, TX510, TX511 ^⑧	12.50 40.00 80.00	40.00 80.00 ..	All All All		3°/m but not greater than 7° 1.5°/m but not greater than 5° 1°/m but not greater than 3°
O, TX510 ^⑧	12.50	..	2.5	..	^⑦
TX511 ^⑧	12.50 40.00 80.00	40.00 80.00 ..	2.5 2.5 2.5	.. .. ..	3°/m but not greater than 7° 1.5°/m but not greater than 5° 1°/m but not greater than 3°

TABLE 12.8 Straightness—Extruded Tube in Straight Lengths

TEMPER	SPECIFIED mm		TOLERANCE ^⑨ ^⑫ —mm
			 D
over	thru		
All except O, TX510 ^⑦ ^⑧	12.50 150.00	150.00 ..	1 mm/m 2 mm/m
O, TX510 ^⑧	12.50	..	^⑦

TABLE 12.9 Flatness (Flat Surfaces)—Extruded Tube

EXCEPT FOR O, T3510, T4510, T6510, T73510, T76510 AND T8510 TEMPERS ^⑦

MINIMUM THICKNESS OF METAL FORMING THE SURFACE mm	TOLERANCE—in.		
	 Y	Maximum Allowable Deviation Y	
		WIDTH (W) UP THRU 25 mm OR ANY 25 mm INCREMENT OF WIDER SURFACES	WIDTH (W) OVER 25 THRU 120 mm
over	thru		
..	5.00	0.15	0.006 · W (mm)
5.00	..	0.10	0.004 · W (mm)

For all numbered footnotes, see page 35.

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**TABLE 12.10 Squareness of Cut Ends—
Extruded Tube**

Allowable deviation from square: 1 degree.

**TABLE 12.11 Corner and Fillet Radii—Extruded
Tube**

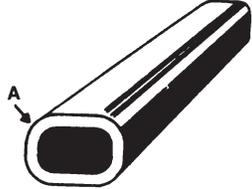
SPECIFIED RADIUS ^⑩ mm		TOLERANCE—mm	
		ALLOWABLE DEVIATION FROM SPECIFIED RADIUS	
			
over	thru	Difference between radius A and specified radius	
Sharp corners		+0.5	
0.50	5.00	±0.5	
5.00	..	±10%	

TABLE 12.12 Angularity—Extruded Tube

Allowable deviation from square: ±2 degrees.

**TABLE 12.13 Surface Roughness ^⑭ ^⑰—
Extruded Tube**

Specified Outside Diameter mm		Specified Wall Thickness mm		Allowable Depth of Conditions ^⑬ mm, max.
over	thru	over	thru	
..	325.00	..	1.60	0.07
		1.60	3.20	0.08
		3.20	5.00	0.09
		5.00	6.30	0.10
		6.30	12.50	0.13
		12.50	..	0.20
325.00	400.00	..	12.50	0.25
		12.50	..	0.30
400.00	500.00	..	12.50	0.30
		12.50	..	0.40
500.00	..	..	12.50	0.40
		12.50	..	0.50

TABLE 12.14 Dents ^⑮—Extruded Tube

Depth of dents shall not exceed twice the tolerances specified in Table 12.2 for diameter at any point from specified diameter, except for tube having a wall thickness less than 2.5 percent of the outside diameter, in which case the following multipliers apply:

2% to 2.5% exclusive—2.5 · tolerance (max.)
 1.5% to 2% exclusive—3.0 · tolerance (max.)
 1% to 1.5% exclusive—4.0 · tolerance (max.)

Footnotes for Tables 12.2 through 12.14

- ① When outside diameter, inside diameter, and wall thickness (or their equivalent dimensions in other than round tube) are all specified, standard tolerances are applicable to any two of these dimensions, but not to all three. When both outside and inside diameters or inside diameter and wall thickness are specified, the tolerance applicable to the specified or calculated O.D. dimension shall also apply to the I.D. dimension.
- ② When a dimension tolerance is specified other than as an equal bilateral tolerance, the value of the standard tolerance is that which applied to the mean of the maximum and minimum dimensions permissible under the tolerance for the dimension under consideration.
- ③ Mean diameter is the average of two diameter measurements taken at right angles to each other at any point along the length.
- ④ Not applicable in the annealed (O) temper if wall thickness is less than 2.5 percent of outside diameter of a circle having a circumference equal to the perimeter of the tube.
- ⑤ The mean wall thickness of round tube is the average of two measurements taken opposite each other. The mean wall thickness of other-than-round tube is the average of two measurements taken opposite each other at approximate center line of tube and perpendicular to the longitudinal axis of the cross section.
- ⑥ When dimensions specified are outside and inside, rather than wall thickness itself, allowable deviation at any point (eccentricity) applies to mean wall thickness.
- ⑦ Tolerances for O, T3510, T4510, T6510, T73510, T76510 and T8510 tempers shall be as agreed upon between purchaser and vendor at the time the contract or order is entered.
- ⑧ TX510 and TX511 are general designations for the following stress-relieved tempers: T3510, T4510, T6510, T8510, T73510, T76510; and T3511, T4511, T6511, T8511, T73511, T76511, respectively.
- ⑨ When mass of piece on flat surface minimizes deviation.
- ⑩ The circumscribing circle diameter is the diameter of the smallest circle that will completely enclose the cross section of the extruded product.

- ⑪ Twist is normally measured by placing the product on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the section and the flat surface. From this measurement, the actual deviation from straightness of the section at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are used to convert angular tolerance to linear deviation:

Tolerance Degrees	Max. Allowable Linear Deviation mm/mm of Width
0.25	0.004
0.5	0.009
1	0.017
1.5	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

- ⑫ Tolerances not applicable to TX510, or TX511 temper tube having a wall thickness less than 2.5 mm.
- ⑬ Conditions include die lines, mandrel lines and handling marks.
- ⑭ For tube over 325 mm O.D. the 2000 and 7000 series alloys and 5000 series alloys with nominal magnesium content of 3 percent or more are excluded.
- ⑮ Not applicable to O temper tube.
- ⑯ Tolerances apply to 5xxx alloys with 4.0% Mg.
- ⑰ Not applicable to 2219 alloy tube. Most tubes in 2219 alloy will have die lines about twice the depth shown in the table; however, for each tube size the supplier should be contacted for the roughness value to apply.
- ⑱ If unspecified, the radius shall be 1 mm maximum including tolerances.

*Table 12.15 intentionally blank***TABLE 12.16 Outside Diameter—Extruded Coiled Tube**

SPECIFIED OUTSIDE DIAMETER mm	TOLERANCE—mm plus and minus	
	ALLOWABLE DEVIATION OF MEAN DIAMETER FROM SPECIFIED DIAMETER	ALLOWABLE DEVIATION OF DIAMETER AT ANY POINT FROM SPECIFIED DIAMETER
6.00 thru 16.00	0.10	0.15

TABLE 12.17 Wall Thickness—Extruded Coiled Tube

SPECIFIED WALL THICKNESS mm	TOLERANCE—mm plus and minus	
	ALLOWABLE DEVIATION OF MEAN WALL THICKNESS FROM SPECIFIED WALL THICKNESS	ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM SPECIFIED WALL THICKNESS
0.80 thru 1.30	0.08	0.10

TABLE 12.18 Coil Length ^①—Extruded Coiled Tube

PERCENT OF COILS IN SHIPMENT	RANGE OF LENGTH
70 min. 30 max.	80 to 120 percent of nominal 60 to 80 percent of nominal

^① Coil size shall be as agreed upon between supplier and purchaser.

Table 12.19 intentionally blank

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TABLE 12.20 Diameter—Drawn Round Tube

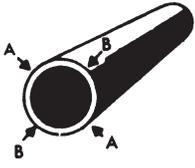
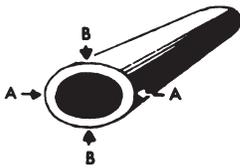
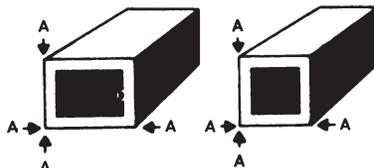
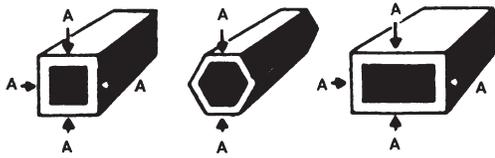
SPECIFIED DIAMETER mm		TOLERANCE ②—mm plus and minus			
		ALLOWABLE DEVIATION OF MEAN DIAMETER ③ FROM SPECIFIED DIAMETER (Size)	ALLOWABLE DEVIATION OF DIAMETER AT ANY POINT FROM SPECIFIED DIAMETER ④		
over	thru	 Difference between ½ (AA + BB) and specified diameter	 Difference between AA or BB and specified diameter		
Col. 1			Col. 2	NON-ANNEALED AND NON-HEAT-TREATED TUBE	HEAT-TREATED TUBE ⑤	ANNEALED TUBE
..	12.50	0.08	0.08	0.16	0.48
12.50	25.00	0.10	0.10	0.20	0.60
25.00	50.00	0.13	0.13	0.25	0.75
50.00	80.00	0.15	0.15	0.30	0.90
80.00	130.00	0.20	0.20	0.41	1.20
130.00	150.00	0.25	0.25	0.50	1.50
150.00	200.00	0.38	0.38	0.76	2.25
200.00	250.00	0.50	0.50	1.00	3.00
250.00	300.00	0.64	0.64	1.25	3.75

TABLE 12.21 Width and Depth—Drawn Square, Rectangular, Hexagonal and Octagonal Tube

SPECIFIED WIDTH OR DEPTH ① mm		TOLERANCE ②—mm plus and minus		
		ALLOWABLE DEVIATION OF WIDTH OR DEPTH AT CORNERS FROM SPECIFIED WIDTH OR DEPTH	ALLOWABLE DEVIATION OF WIDTH OR DEPTH NOT AT CORNERS FROM SPECIFIED WIDTH OR DEPTH ④ ⑦	
Col. 1		 Difference between AA and specified width or depth	 Difference between AA and specified width, depth, or distance across flats	
			SQUARE, RECTANGULAR	SQUARE, HEXAGONAL, OCTAGONAL	RECTANGULAR
Col. 1		Col. 2	Col. 3	Col. 4
..	12.50	0.08	0.16	The tolerance for the width is the value in Col. 3 for the dimension equal to the depth, and conversely, but in no case is the tolerance less than at the corners. ⑥
12.50	25.00	0.10	0.20	
25.00	50.00	0.13	0.25	
50.00	80.00	0.15	0.30	
80.00	130.00	0.20	0.41	
130.00	150.00	0.25	0.50	
150.00	200.00	0.38	0.76	
200.00	250.00	0.50	1.00	
250.00	300.00	0.64	1.25	

Footnotes for Tables 12.20 and 12.21

- ① When outside diameter, inside diameter, and wall thickness (or their equivalent dimensions in other than round tube) are all specified, standard tolerances are applicable to any two of these dimensions, but not to all three. When both outside and inside diameters or inside diameter and wall thickness are specified, the tolerance applicable to the specified or calculated O.D. dimension shall also apply to the I.D. dimension.
- ② When a dimension tolerance is specified other than as an equal bilateral tolerance, the value of the standard tolerance is that which applies to the mean of the maximum and minimum dimensions permissible under the tolerance of the dimension under consideration.
- ③ Mean diameter is the average of two diameter measurements taken at right angles to each other at the same longitudinal location on the tube.

- ④ Not applicable to coiled tube or tube having a wall thickness less than 2.5 percent of the specified outside diameter. The tolerance for tube with wall thickness less than 2.5 percent of the specified outside diameter is determined by multiplying the applicable tolerance in columns 3 thru 5 as follows:
 2% to 2.5% exclusive—1.5 · tolerance
 1.5% to 2% exclusive—2.0 · tolerance
 1% to 1.5% exclusive—3.0 · tolerance
 0.5% to 1% exclusive—4.0 · tolerance
- ⑤ For the T8 tempers of 6063 the tolerance in Column 3 apply.
- ⑥ Example: The width tolerance of 25 · 75 mm rectangular tube is plus and minus 0.20 mm, and the depth tolerance is plus and minus 0.30 mm.
- ⑦ Not applicable to annealed (O temper) tube.

TABLE 12.22 Diameter—Drawn Oval, Elliptical and Streamline Tube

EQUIVALENT ROUND DIAMETER ^⑤ mm		TOLERANCE ^{① ②} —mm			
		LENGTH OF MAJOR AXIS, mm		LENGTH OF MAJOR AXIS, mm	
over	thru	Difference between AA and specified length		Difference between AA and specified length	
Col. 1	Col. 2	Col. 2		Col. 3	
..	70.00	+1.00	-0.64	+0.64	-0.38
70.00	110.00	+1.25	-0.90	+0.90	-0.64
110.00	150.00	+1.80	-1.25	+1.40	-1.00
150.00	200.00	+2.55	-2.15	+2.05	-1.60
200.00	250.00	+4.05	-3.55	+2.90	-2.15

TABLE 12.23 Corner Radii—Drawn Tube

SPECIFIED ^⑦ RADIUS mm		TOLERANCE—mm
		ALLOWABLE DEVIATION FROM SPECIFIED RADIUS
over	thru	Difference between radius A and specified radius
Sharp Corners		
0.50	5.00	±0.5
5.00	..	±10%

TABLE 12.24 Wall Thickness—Drawn Round and Other-Than-Round Tube

SPECIFIED THICKNESS ^④ mm		TOLERANCE ^{① ②} —mm plus and minus			
		ALLOWABLE DEVIATION OF MEAN WALL THICKNESS ^③ FROM SPECIFIED WALL THICKNESS		ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM SPECIFIED WALL THICKNESS (Eccentricity)	
over	thru	Difference between ½(AA+BB) and specified wall thickness		ROUND, NON-HEAT-TREATABLE ALLOYS ^⑥	ROUND, HEAT-TREATABLE ALLOYS AND OTHER THAN ROUND, ALL ALLOYS
Col. 1	Col. 2	Col. 2		Col. 3	Col. 4
0.23	0.80	0.05		0.05	Plus and minus 10% of specified wall thickness, min ±0.08
0.80	1.20	0.08		0.08	
1.20	2.00	0.10		0.10	
2.00	3.20	0.13		0.15	
3.20	5.00	0.15		0.20	
5.00	8.00	0.20		0.30	
8.00	10.00	0.38		0.50	
10.00	12.50	0.50		0.76	

Footnotes for Tables 12.22 Through 12.24

① When outside diameter, inside diameter, and wall thickness (or their equivalent dimensions in other-than-round tube) are all specified, standard tolerances are applicable to any two of these dimensions, but not to all three. When both outside and inside diameters or inside diameter and wall thickness are specified, the tolerance applicable to the specified or calculated O.D. dimension shall also apply to the I.D. dimension.
 ② When a dimension tolerance is specified other than as an equal bilateral tolerance, the value of the standard tolerance is that which applies to the mean of the maximum and minimum dimensions permissible under the tolerance for the dimension under consideration.

③ The mean wall thickness of round tube is the average of two measurements taken opposite each other. The mean wall thickness of other-than-round tube is the average of two measurements taken opposite each other at approximate center line of tube and perpendicular to the longitudinal axis of the cross section.
 ④ When dimensions specified are outside and inside, rather than wall thickness itself, allowable deviation at any point (eccentricity) is plus and minus 10 percent of the mean wall thickness but not less than ±0.08 mm.
 ⑤ Equivalent round diameter is the diameter of the circle having a circumference equal to the perimeter of the tube.
 ⑥ For coiled tube, values in Column 4 apply.
 ⑦ If unspecified, the radius shall be 1 mm maximum including tolerances.

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TABLE 12.25 Straightness—Drawn Tube

SPECIFIED OUTSIDE DIAMETER OR WIDTH mm		TOLERANCE ① ②—mm	
		 D(max) Allowable deviation from straight, D(max), in total length or in any 300 mm or longer chord segment of total length	
over	thru		
..	9.50	42 mm/m	
9.50	150.00	1 mm/m	
150.00	..	2 mm/m	

TABLE 12.26 Twist ④—Drawn Tube

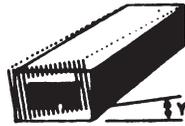
SPECIFIED WIDTH mm		TOLERANCE ① ②—Degree	
		 Y (max) in degrees Allowable deviation from straight, y(max), in total length or in any 300 mm or longer chord segment of total length.	
over	thru		
..	40.00	3°/m but not greater than 7°	
40.00	80.00	1.5°/m but not greater than 5°	
80.00	..	1°/m but not greater than 3°	

TABLE 12.27 Length—Drawn Tube

SPECIFIED OUTSIDE DIAMETER OR WIDTH mm		TOLERANCE—mm plus excepted as noted								
		ALLOWABLE DEVIATION FROM SPECIFIED LENGTH								
		STRAIGHT					COILED			
		SPECIFIED LENGTH—mm								
over	thru	Up thru 5 000	Over 5 000 thru 10 000	Over 10 000 thru 15 000	Over 15 000	Up thru 30 000	Over 30 000 thru 75 000	Over 75 000 thru 150 000	Over 150 000	
..	6.30	7	10	13	..	+5%, -0%	±10%	±15%	±20%	
6.30	35.00	4	7	10	25	+5%, -0%	±10%	±15%	±20%	
35.00	70.00	4	7	10	25	..	..	..	..
70.00	200.00	6	9	11	25	..	..	..	..
200.00	..	7	10	13	25	..	..	..	..

TABLE 12.28 Flatness (Flat Surfaces)—Other-Than-Round Drawn Tube

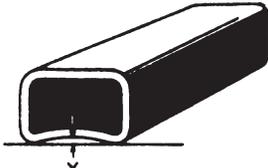
SPECIFIED WIDTH OR DEPTH mm		TOLERANCE ③—mm	
		 ALLOWABLE DEVIATION FROM FLAT Maximum allowable distance Y	
over	thru		
..	12.50	0.08	
12.50	25.00	0.10	
25.00	50.00	0.13	
50.00	80.00	0.15	
80.00	130.00	0.20	
130.00	150.00	0.25	
150.00	200.00	0.38	
200.00	250.00	0.50	
250.00	300.00	0.64	

TABLE 12.30 Angularity—Drawn Tube

Allowable deviation from specified angle: ±2 degrees

Footnotes for Tables 12.25 Through 12.30

- ① Tolerance is applicable when mass of tube on flat surface minimizes deviation.
- ② Not applicable to annealed (O temper) tube.
- ③ Not applicable to annealed (O temper) tube, coiled tube, or tube having a wall thickness less than 0.50 mm or less than 2½% of the equivalent round diameter. Equivalent round diameter is the diameter of a circle having a circumference equal to the perimeter of the tube.
- ④ Twist is normally measured by placing the product on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the section and the flat surface. From this measurement, the actual deviation from straightness of the section at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are used to convert angular tolerance to linear deviation:

Tolerance Degrees	Max. Allowable Linear Deviation mm/mm of Width
0.25	0.004
0.5	0.009
1	0.017
1.5	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

TABLE 12.29 Squareness of Cut Ends—Drawn Tube

Allowable deviation from square: 1 degree

TABLE 12.31 Surface Roughness—Drawn Tube^②

Depth of surface conditions shall not exceed 10% of the smaller (or nominal) wall thickness or 0.13 mm, whichever is smaller.

^② Not applicable to annealed (O temper) tube.

TABLE 12.32 Dents—Drawn Tube

SPECIFIED DIAMETER	TOLERANCES—mm			
	NON-ANNEALED AND NON-HEAT-TREATED TUBE		HEAT-TREATED TUBE ^⑤	ANNEALED TUBE
	over	thru		
Col. 1	Col. 2	Col. 3	Col. 4	
..	12.50	0.08	0.16	0.48
12.50	25.00	0.10	0.20	0.60
25.00	50.00	0.13	0.25	0.75
50.00	80.00	0.15	0.30	0.90
80.00	130.00	0.20	0.41	1.20
130.00	150.00	0.25	0.50	1.50
150.00	200.00	0.38	0.76	2.25
200.00	250.00	0.50	1.00	3.00
250.00	300.00	0.64	1.25	3.75

Depth of dents shall not exceed twice the tolerances specified in table 12.32 at any point from specified diameter with the following exception.

For tube having a wall thickness less than 2.5 percent of the outside diameter, the following multipliers of the above tolerances apply.

Percent of Wall Thickness

- 2% to 2.5% exclusive—1.25 · tolerance (max.)
- 1.5% to 2% exclusive—1.50 · tolerance (max.)
- 1% to 1.5% exclusive—2.0 · tolerance (max.)
- 0.5% to 1% exclusive—2.5 · tolerance (max.)

^⑤ For the T8 tempers of 6063 the tolerances of Column 2 apply.

Table 12.33 intentionally blank

TABLE 12.34 Outside Diameter Tolerances—Heat-Treatable Heat Exchanger Tube

SPECIFIED OUTSIDE DIAMETER, mm		TOLERANCE ^① mm plus and minus
over	thru	
..	12.50	0.08
12.50	25.00	0.10
25.00	40.00	0.13
40.00	50.00	0.15

TABLE 12.35 Outside Diameter Tolerances—Non-Heat-Treatable Heat Exchanger Tube

SPECIFIED OUTSIDE DIAMETER, mm		TOLERANCE ^① mm plus and minus
over	thru	
..	12.50	0.05
12.50	20.00	0.06
20.00	25.00	0.08
25.00	30.00	0.09
30.00	50.00	0.10

TABLE 12.36 Wall Thickness Tolerances—Heat Exchanger Tube

SPECIFIED WALL THICKNESS, mm		TOLERANCE—mm plus	
		ALLOWABLE DEVIATION OF MEAN ^② WALL THICKNESS FROM SPECIFIED WALL THICKNESS	ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM SPECIFIED WALL THICKNESS (Eccentricity)
over	thru		
..	0.80	0.10	0.15
0.80	1.20	0.15	0.22
1.20	1.60	0.20	0.30
1.60	2.00	0.25	0.38
2.00	2.50	0.30	0.46
2.50	3.20	0.36	0.56
3.20	4.00	0.45	0.70
4.00	5.00	0.60	0.90

TABLE 12.37 Length Tolerances—Heat Exchanger Tube

SPECIFIED LENGTH		TOLERANCE—mm plus
over	thru	
..	5 000	2.5
5 000	10 000	5
10 000	20 000	7

TABLE 12.38 Straightness Tolerances—Heat Exchanger Tube

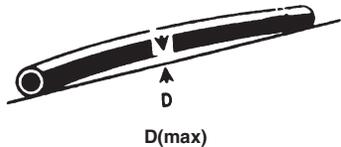
SPECIFIED OUTSIDE DIAMETER mm		TOLERANCE ^③ —mm
		 <p>D(max)</p> <p>Allowable deviation from straight, D(max), in total length or in any 300 mm or longer chord segment of total length</p>
over	thru	
9.00	50.00	1 mm/m

TABLE 12.39 Squareness of Cut Ends—Heat Exchanger Tube

Allowable deviation from square: 1 degree

Footnotes for Tables 12.34 Through 12.39

- ^① As measured by use of “go” or “no go” ring gages.
- ^② Mean wall thickness is the average of two measurements taken opposite each other.
- ^③ Tolerance is applicable when weight of tube on flat surface minimizes deviation.

Table 12.40 intentionally blank

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TABLE 12.41 Diameter Tolerances—Welded Round Tube

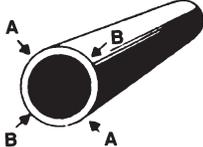
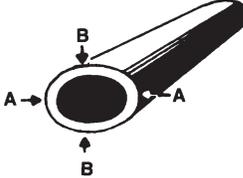
SPECIFIED DIAMETER ① mm		TOLERANCE ①—mm plus and minus	
		ALLOWABLE DEVIATION OF MEAN DIAMETER ② FROM SPECIFIED DIAMETER (Size)	ALLOWABLE DEVIATION OF DIAMETER AT ANY POINT FROM SPECIFIED DIAMETER
		 <p>Difference between $\frac{1}{2}(AA+BB)$ and specified diameter</p>	 <p>Difference between AA or BB and specified diameter</p>
over	thru	Col. 1	Col. 2
12.50	25.00		0.10
25.00	50.00		0.13
		Col. 3	Col. 3
			0.20
			0.25

TABLE 12.42 Width and Depth Tolerances—Welded Square Tube

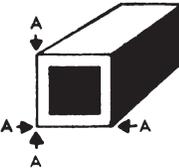
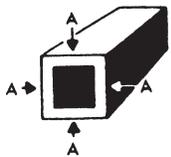
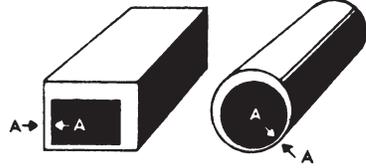
SPECIFIED WIDTH OR DEPTH mm		TOLERANCE ①—mm plus and minus	
		ALLOWABLE DEVIATION OF WIDTH OR DEPTH AT CORNERS FROM SPECIFIED WIDTH OR DEPTH	ALLOWABLE DEVIATION OF WIDTH OR DEPTH NOT AT CORNERS FROM SPECIFIED WIDTH OR DEPTH
		 <p>Difference between AA and specified width or depth</p>	 <p>Difference between AA and specified width or depth</p>
over	thru	Col. 1	Col. 2
12.50	25.00		0.13
25.00	50.00		0.15

TABLE 12.43 Wall Thickness Tolerances—Welded Round and Square Tube

SPECIFIED THICKNESS mm		TOLERANCE ③—mm plus
		ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM SPECIFIED WALL THICKNESS
		
over	thru	
0.63	1.00	0.10
1.00	2.00	0.13

Footnotes for Tables 12.41 Through 12.43

① When a dimension tolerance is specified other than as an equal bilateral tolerance, the value of the standard tolerance is that which applies to the mean of the maximum and minimum dimension permissible under the tolerance for the dimension under consideration.

② Mean diameter is the average of two diameter measurements taken at right angle to each other at any point along the length.
 ③ Not applicable to the weld area or to embossed tube.

TABLE 12.44 Length Tolerances—Welded Tube

SPECIFIED OUTSIDE DIAMETER OR WIDTH mm	TOLERANCE—mm					
	ALLOWABLE DEVIATION FROM SPECIFIED LENGTH					
	SPECIFIED LENGTH—mm					
	Up thru 3 000		Over 3 000 thru 6 000		Over 6 000 thru 12 000	
Plus	Minus	Plus	Minus	Plus	Minus	
Up thru 50.00	4	0	6	0	10	0

TABLE 12.45 Straightness Tolerances—Welded Tube

SPECIFIED OUTSIDE DIAMETER OR WIDTH mm	TOLERANCE ①—mm	
	 <p>D(max)</p>	
	Allowable deviation from straight, D(max), in total length or in any 300 mm or longer chord segment of total length.	
over	thru	
12.50	25.00	2.5 mm/m
25.00	50.00	3.5 mm/m

TABLE 12.46 Twist ② Tolerances—Welded Tube

SPECIFIED WIDTH mm	TOLERANCE ①—Degrees	
	 <p>Y (max) in degrees</p>	
Allowable deviation from straight, Y(max), in total length or in any 300 mm or longer chord segment of total length.		
over	thru	
..	40.00	3°/m but not greater than 7°
40.00	50.00	1.5°/m but not greater than 5°

TABLE 12.47 Squareness of Cut Ends—Welded Tube

Allowable deviation from square: 1 degree

Footnotes for Tables 12.44 Through 12.47

- ① Tolerance is applicable when weight of tube on flat surface minimizes deviation.
- ② Twist is normally measured by placing the product on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the section and the flat surface. From this measurement, the actual deviation from straightness of the section at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are used to convert angular tolerance to linear deviation:

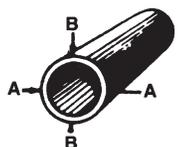
Tolerance Degrees	Max. Allowable Linear Deviation mm/mm of Width
0.25	0.004
0.5	0.009
1	0.017
1.5	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

Table 12.48 intentionally blank

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Extruded Pipe or Extruded and Drawn Pipe

**TABLE 12.49 Outside Diameter Tolerances—
Extruded Pipe or Extruded and
Drawn Pipe**

PIPE SIZE mm	TOLERANCE—mm	
	Allowable deviation of mean ^② diameter from nominal diameter ^①	Allowable deviation of diameter at any point from nominal diameter ^{① ⑦}
		
	Difference between ½(AA+BB) and nominal diameter	Difference between AA and nominal diameter
	SCHEDULES 5 AND 10	SCHEDULE 20 AND GREATER
Under 2	+0.40, -0.80	+ .40, -.80
2-4	+0.80, -0.80	+1%, -1%
5-7	+1.60, -0.80	+1%, -1%
8-12	+2.40, -0.80	+1%, -1%

**TABLE 12.50 Wall Thickness Tolerances—
Extruded Pipe or Extruded and
Drawn Pipe**

SCHEDULE NUMBER	TOLERANCE
	ALLOWABLE DEVIATION OF WALL THICKNESS AT ANY POINT FROM NOMINAL ^① WALL THICKNESS
5 and 10 20 and greater	±12.5%, ±0.30 mm min. -12.5% ^③

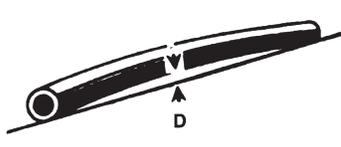
**TABLE 12.51 Weight Tolerances—Extruded Pipe
or Extruded and Drawn Pipe**

SCHEDULE NUMBER	TOLERANCE
	ALLOWABLE DEVIATION FROM THEORETICAL WEIGHT
5 and 10 20 and greater	^⑤ +8% ^⑥

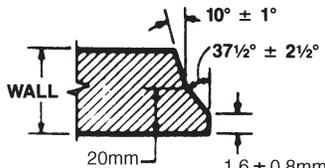
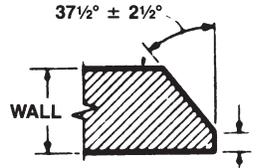
**TABLE 12.52 Length Tolerances—Extruded Pipe
or Extruded and Drawn Pipe**

SPECIFIED LENGTH mm		TOLERANCE mm plus
over	thru	ALLOWABLE DEVIATION FROM SPECIFIED LENGTH
..	6 000	6
6 000	12 000	13

**TABLE 12.53 Straightness Tolerances—
Extruded Pipe or Extruded and
Drawn Pipe**

PIPE SIZE	TOLERANCE ^④ —mm
	
	Allowable deviation from straight, D(max), in total length or in any 300 mm or longer chord segment of total length.
Under 6	1 mm/m
6-12	2 mm/m

**TABLE 12.54 Standard Welding Bevels—
Extruded Pipe or Extruded and
Drawn Pipe**

DOUBLE LEVEL For Wall Thickness Over 20.00 mm	STRAIGHT BEVEL For Wall Thickness up thru 20.00 mm
	

Footnotes for Tables 12.49 Through 12.54

- ① Nominal diameter and wall thickness are those listed in Table 12.55.
- ② Mean diameter is the average of any two diameter measurements taken at right angles to each other at any point along the length.
- ③ Maximum wall thickness is controlled by mass tolerance.
- ④ When mass of pipe on flat surface minimizes deviation.

- ⑤ For schedule 5 and 10, only diameter, wall thickness and length tolerances apply.
- ⑥ Minimum weight is controlled by tolerances for outside diameter and wall thickness.
- ⑦ The 1 percent tolerances are rounded to the nearest 0.1 mm before applying the tolerance.

TABLE 12.55 Diameters, Wall Thicknesses, Weights—Pipe

PIPE SIZE ① DESIGNATION	SCHEDULE NUMBER	OUTSIDE DIAMETER mm			INSIDE DIAMETER mm	WALL THICKNESS mm			MASS PER METRE g	
		Nom. ①	Min. ② ④	Max. ② ④	Nom.	Nom. ①	Min. ②	Max. ②	Nom. ③	Max. ② ③
1/8	40	10.30	9.50	10.70	6.84	1.73	1.51	..	0.13	0.14
	80	10.30	9.50	10.70	5.48	2.41	2.11	..	0.16	0.17
1/4	40	13.70	12.90	14.10	9.22	2.24	1.96	..	0.22	0.24
	80	13.70	12.90	14.10	7.66	3.02	2.64	..	0.27	0.29
3/8	40	17.10	16.30	17.50	12.48	2.31	2.02	..	0.29	0.31
	80	17.10	16.30	17.50	10.70	3.20	2.80	..	0.38	0.41
1/2	40	21.30	20.50	21.70	15.76	2.77	2.42	..	0.44	0.48
	80	21.30	20.50	21.70	13.84	3.73	3.26	..	0.56	0.60
	160	21.30	20.50	21.70	11.74	4.78	4.18	..	0.67	0.72
3/4	40	26.70	25.90	27.10	20.96	2.87	2.51	..	0.58	0.63
	80	26.70	25.90	27.10	18.88	3.91	3.42	..	0.76	0.82
	160	26.70	25.90	27.10	15.58	5.56	4.86	..	1.00	1.08
1	40	33.40	32.60	33.80	26.64	3.38	2.96	..	0.86	0.93
	80	33.40	32.60	33.80	24.30	4.55	3.98	..	1.11	1.20
	160	33.40	32.60	33.80	20.70	6.35	5.56	..	1.46	1.58
1 1/4	40	42.20	41.40	42.60	35.08	3.56	3.12	..	1.17	1.26
	80	42.20	41.40	42.60	32.50	4.85	4.24	..	1.54	1.66
	160	42.20	41.40	42.60	29.50	6.35	5.56	..	1.93	2.08
1 1/2	40	48.30	47.50	48.70	40.94	3.68	3.22	..	1.39	1.50
	80	48.30	47.50	48.70	38.14	5.08	4.44	..	1.86	2.01
	160	48.30	47.50	48.70	34.02	7.14	6.25	..	2.49	2.69
2	40	60.30	59.70	60.90	52.48	3.91	3.42	..	1.87	2.02
	80	60.30	59.70	60.90	49.22	5.54	4.85	..	2.57	2.78
	160	60.30	59.70	60.90	42.82	8.74	7.65	..	3.82	4.13
2 1/2	40	73.00	72.30	73.70	62.68	5.16	4.52	..	2.97	3.21
	80	73.00	72.30	73.70	58.98	7.01	6.13	..	3.92	4.23
	160	73.00	72.30	73.70	53.94	9.53	8.34	..	5.13	5.54
3	40	88.90	88.00	89.80	77.92	5.49	4.80	..	3.88	4.19
	80	88.90	88.00	89.80	73.66	7.62	6.67	..	5.25	5.67
	160	88.90	88.00	89.80	66.64	11.13	9.74	..	7.34	7.93
3 1/2	40	101.60	100.60	102.60	90.12	5.74	5.02	..	4.67	5.04
	80	101.60	100.60	102.60	85.44	8.08	7.07	..	6.41	6.92

For all numbered footnotes, see page 45.

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TABLE 12.55 Diameters, Wall Thicknesses, Weights (concluded)

PIPE SIZE ① DESIGNATION	SCHEDULE NUMBER	OUTSIDE DIAMETER mm			INSIDE DIAMETER mm	WALL THICKNESS mm			MASS PER METRE g	
		Nom. ①	Min. ② ④	Max. ② ④	Nom.	Nom. ①	Min. ②	Max. ②	Nom. ③	Max. ② ③
4	40	114.30	113.20	115.40	102.26	6.02	5.27	..	5.53	5.97
	80	114.30	113.20	115.40	97.18	8.56	7.49	..	7.68	8.29
	120	114.30	113.20	115.40	92.04	11.13	9.74	..	9.74	10.53
	160	114.30	113.20	115.40	87.32	13.49	11.80	..	11.54	12.45
5	40	141.30	139.90	142.70	128.20	6.55	5.73	..	7.49	8.09
	80	141.30	139.90	142.70	122.24	9.53	8.34	..	10.65	11.50
	120	141.30	139.90	142.70	115.90	12.70	11.11	..	13.85	14.96
	160	141.30	139.90	142.70	109.54	15.88	13.90	..	16.89	18.24
6	40	168.30	166.60	170.00	154.08	7.11	6.22	..	9.72	10.50
	80	168.30	166.60	170.00	146.36	10.97	9.60	..	14.64	15.81
	120	168.30	166.60	170.00	139.76	14.27	12.49	..	18.64	20.13
	160	168.30	166.60	170.00	131.78	18.26	15.98	..	23.24	25.10
8	20	219.10	216.90	221.30	206.40	6.35	5.56	..	11.46	12.38
	30	219.10	216.90	221.30	205.02	7.04	6.16	..	12.66	13.67
	40	219.10	216.90	221.30	202.74	8.18	7.16	..	14.63	15.80
	60	219.10	216.90	221.30	198.48	10.31	9.02	..	18.26	19.72
	80	219.10	216.90	221.30	193.70	12.70	11.11	..	22.23	24.01
	100	219.10	216.90	221.30	188.92	15.09	13.20	..	26.11	28.21
	120	219.10	216.90	221.30	182.58	18.26	15.98	..	31.11	33.60
	140	219.10	216.90	221.30	177.86	20.62	18.04	..	34.72	37.50
	160	219.10	216.90	221.30	173.08	23.01	20.13	..	38.27	41.33
	10	20	273.10	270.40	275.80	260.40	6.35	5.56	..	14.37	15.52
30		273.10	270.40	275.80	257.50	7.80	6.82	..	17.55	18.95
40		273.10	270.40	275.80	254.56	9.27	8.11	..	20.75	22.41
60		273.10	270.40	275.80	247.70	12.70	11.11	..	28.05	30.29
80		273.10	270.40	275.80	242.92	15.09	13.20	..	33.02	35.66
100		273.10	270.40	275.80	236.58	18.26	15.98	..	39.47	42.63
12	20	323.90	320.70	327.10	311.20	6.35	5.56	..	17.10	18.47
	30	323.90	320.70	327.10	307.14	8.38	7.33	..	22.43	24.22
	40	323.90	320.70	327.10	303.28	10.31	9.02	..	27.42	28.61
	60	323.90	320.70	327.10	295.36	14.27	12.49	..	37.48	40.48
	80	323.90	320.70	327.10	288.94	17.48	15.30	..	45.43	49.06

Footnotes for Table 12.55

① In accordance with ANSI/ASME Standards B36.10M and B36.19M

② Based on standard tolerances for outside diameter, wall thickness and weight shown earlier in this section.

③ Based on nominal dimensions, plain ends, and a density of 2700 kg/m³ for alloy 6061. For alloy 6063 multiply by 0.99 and for alloy 3003 multiply by 1.011.

④ For schedules 5 and 10 these values apply to mean outside diameters.

13. Structural Profiles

Tolerance limits for aluminum alloy structural profiles are identical with those for other extruded profiles as shown in Section 11.

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14. Forging Stock

TABLE 14.1 Diameter ^①—Round Forging Stock

CLASS 1. FORGING STOCK				CLASS 2. FORGING STOCK		
SPECIFIED DIAMETER mm		TOLERANCE mm plus and minus		SPECIFIED DIAMETER mm		TOLERANCE mm plus and minus
over	thru	ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER	CONDITIONING ALLOWANCE ^②	over	thru	ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER
10.00	12.50	0.38	-1	10.00	12.50	0.040
12.50	25.00	0.38	-1	12.50	25.00	0.050
25.00	40.00	0.38	-1	25.00	40.00	0.06
40.00	80.00	0.38	-1	40.00	80.00	0.20
80.00	130.00	0.78	-2	..	..	..
100.00	200.00	1.60	-2	..	..	..

TABLE 14.2 Distance Across Flats ^①—Square Forging Stock

CLASS 1. FORGING STOCK				CLASS 2. FORGING STOCK		
SPECIFIED DISTANCE ACROSS FLATS mm		TOLERANCE mm plus and minus		SPECIFIED DISTANCE ACROSS FLATS mm		TOLERANCE mm plus and minus
over	thru	ALLOWABLE DEVIATION FROM SPECIFIED DISTANCE ACROSS FLATS	CONDITIONING ALLOWANCE ^②	over	thru	ALLOWABLE DEVIATION FROM SPECIFIED DISTANCE ACROSS FLATS
10.00	12.50	0.25	-1 on face	10.00	12.50	0.050
12.50	25.00	0.38	-1 on face	12.50	25.00	0.06
25.00	50.00	0.46	-1 on face	25.00	40.00	0.08
50.00	80.00	0.50	-1 on face	40.00	100.00	0.13
80.00	100.00	0.80	-1 on face	..	..	..

TABLE 14.3 Thickness and Width ^①—Rectangular Forging Stock

CLASS 1. FORGING STOCK						CLASS 2. FORGING STOCK				
SPECIFIED THICKNESS mm		TOLERANCE mm plus and minus		SPECIFIED WIDTH mm		TOLERANCE mm plus and minus		SPECIFIED THICKNESS OR WIDTH mm		TOLERANCE mm plus and minus
over	thru	ALLOWABLE DEVIATION FROM SPECIFIED THICKNESS	CONDITIONING ALLOWANCE ^②	over	thru	ALLOWABLE DEVIATION FROM SPECIFIED WIDTH	CONDITIONING ALLOWANCE ^②	over	thru	ALLOWABLE DEVIATION FROM SPECIFIED THICKNESS OR WIDTH
10.00	12.50	0.25	-1 on face	..	40.00	0.46	-2 on face	10.00	12.50	0.050
12.50	25.00	0.38	-1 on face	40.00	100.00	0.76	-2 on face	12.50	25.00	0.06
25.00	50.00	0.46	-1 on face	100.00	150.00	1.20	-2 on face	25.00	40.00	0.08
50.00	80.00	0.50	-1 on face	150.00	250.00	1.60	-2 on face	40.00	100.00	0.13

TABLE 14.4 Length ^①—Specific and Multiple—Forging Stock

SPECIFIED DIAMETER, WIDTH OR DISTANCE ACROSS FLATS mm		TOLERANCE—mm plus			
		ALLOWABLE DEVIATION FROM SPECIFIED LENGTH			
		SPECIFIED LENGTH—mm			
over	thru	Thru 5 000	Over 5 000 thru 10 000	Over 10 000 thru 15 000	Over 15 000
..	70.00	4	7	10	25
70.00	200.00	6	9	11	25
200.00	..	7	10	13	25

Footnotes for Tables 14.1 and 14.4

① These tolerances are applicable for forging stock in rod and bar form. Standard tolerances for forging stock in sheet and plate form are as indicated in the section on Sheet and Plate.

② Conditioning allowance is an additional tolerance at localized areas to permit removal of possible surface defects.

15. Hand Forgings

Tables 15.1 and 15.2 intentionally blank

TABLE 15.3 Standard Tolerances ^① For Hand Forgings

ORDERED LENGTH mm		STRAIGHTNESS ^② mm	DIMENSIONAL TOLERANCES		
over	thru		THICKNESS mm, plus	WIDTH ^③ mm, plus	LENGTH mm, plus
..	2000	6.50	6.50	10.00	25.00
2000	4000	10.00	6.50	12.00	25.00
4000	..	12.00	10.00	20.00	25.00

^① Corner radii may vary from 0 to 12 mm.

^② As measured with the hand forging resting on a flat surface.

^③ Measured exclusive of edge bulges typically present on compression cold work forgings.

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16. Electrical Conductors

16. Wire, Rod, and Bar—Rolled or Cold-finished

Tables 16.1– 16.6 intentionally blank

TABLE 16.7 Diameter—Tolerances—Cold-Finished Wire—Electric Conductors

SPECIFIED WIDTH mm		TOLERANCE mm plus and minus or percent
Over	thru	ALLOWABLE DEVIATION OF MEAN ^① DIAMETER FROM SPECIFIED DIAMETER
0.25	1.00	.015
1.00	2.50	.025
2.50	6.50	1%

TABLE 16.8 Diameter—Tolerances—Drawing Stock—Electric Conductors

SPECIFIED WIDTH mm		TOLERANCE—mm plus and minus
Over	thru	ALLOWABLE DEVIATION FROM SPECIFIED DIAMETER
9.50	12.50	0.50
12.50	25.00	0.65

TABLE 16.9 Diameter—Tolerances—Magnet Wire—Electric Conductors

SPECIFIED DIAMETER		TOLERANCE—mm plus and minus
over	thru	ALLOWABLE DEVIATION OF MEAN ^① DIAMETER FROM SPECIFIED DIAMETER
..	0.25	0.003
0.25	0.50	0.005
0.50	0.75	0.008
0.75	1.00	0.010
1.00	1.25	0.013
1.25	1.50	0.015
1.50	2.00	0.020
2.00	3.75	0.025
3.75	6.50	0.038

TABLE 16.10 Thickness—Tolerances—Rolled Bar—Electric Conductors

SPECIFIED THICKNESS mm		TOLERANCE mm plus and minus
Over	thru	ALLOWABLE DEVIATION FROM SPECIFIED THICKNESS
3.20	12.50	0.15
12.50	20.00	0.20
20.00	25.00	0.30
25.00	50.00	0.50

Footnotes for Tables 16.7 Through 16.14

① Mean diameter is the average of two measurements taken at right angles to each other at any point along the length. At least three such measurements are made, one near each end and one near the middle of the coil.

② When mass of piece on flat surface minimizes deviation.

③ Straightness shall be measured by placing the bar on a level table so that the arc or departure from straightness is horizontal. Measure the maximum depth of arc to the market 0.8 mm using a steel scale and a straightedge.

TABLE 16.11 Width—Tolerances—Rolled Bar—Electric Conductors

SPECIFIED WIDTH mm		TOLERANCE mm plus and minus
Over	thru	ALLOWABLE DEVIATION FROM SPECIFIED WIDTH
12.50	40.00	0.40
40.00	100.00	0.80
100.00	150.00	1.20
150.00	300.00	1.60

TABLE 16.12 Length—Tolerances—Rolled Bar and Sawed-Plate Bar—Electric Conductors

SPECIFIED WIDTH		TOLERANCE—mm plus	
Over	thru	Up thru 5 000	Over 5 000
..	90.00	3	6
90.00	..	6	6

TABLE 16.13 Straightness—Tolerances—Rolled Bar and Sawed-Plate Bar—Electric Conductors

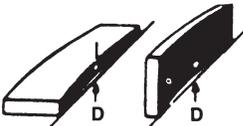
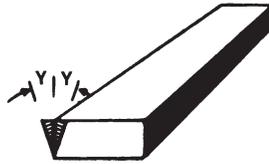
TOLERANCE ^② ③—mm
Maximum Curvature (Depth of Arc)

D (max.) = 4 mm in any 1 m of chord length

TABLE 16.14 Flatness (Flat Surfaces)—Tolerances—Rolled Bar and Sawed-Plate Bar—Electric Conductors

SPECIFIED WIDTH mm		TOLERANCE—mm
over	thru	Maximum Allowable Deviation D
..	25	0.10
25	..	.004 · W(mm)
in any 25 mm of width		0.10

TABLE 16.15 Angularity—Rolled Bar—Electric Conductors



Allowable deviation from nominal angle: ±1 degree.

TABLE 16.16 Squareness of Saw Cuts—Rolled Bar—Electric Conductors

Allowable deviation from square: 1 degree.

TABLE 16.17 Corner and Edge Radii—Tolerances with Rolled Bar—Electric Conductors

	SPECIFIED EDGE CONTOUR	SPECIFIED BAR THICKNESS mm		NOMINAL RADIUS	RADIUS TOLERANCE
		over	thru		
Square Corners		3.20 25.00	25.00 ..	.. ..	+1 mm +2 mm
Round Corners	Radius	3.20 5.00 25.00	5.00 25.00 ..	1 mm 2 mm 4 mm	±0.5 mm ±0.5 mm ±0.5 mm
Rounded Edge	Radius Blended Corners	3.20	..	1.25 · Bar thickness	±0.25 · Bar thickness
Full Rounded Edge	Radius	All		0.5 · Bar thickness	+25%

TABLE 16.18 Thickness—Tolerances—Sawed-Plate Bar—Electric Conductors

SPECIFIED THICKNESS mm		TOLERANCE mm plus and minus
over	thru	ALLOWABLE DEVIATION FROM SPECIFIED THICKNESS
6.30	8.00	0.32
8.00	10.00	0.44
10.00	16.00	0.60
16.00	25.00	0.80
25.00	40.00	1.00
40.00	60.00	1.30
60.00	80.00	1.80

Footnotes for Tables 16.14 Through 16.19

① Twist is normally measured by placing the product on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the section and the flat surface. From this measurement, the actual deviation from straightness of the section at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface. The following values are used to convert angular tolerance to linear deviation:

Tolerance Degrees	Max. Allowable Linear Deviation mm/mm of Width
0.25	0.004
0.5	0.009
1	0.017
1.5	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

② When mass of bar on flat surface minimizes deviation.

TABLE 16.19 Twist ②—Tolerances—Rolled Bar and Sawed-Plate Bar—Electric Conductors

SPECIFIED WIDTH		TOLERANCE ②-DEGREES
		Allowable Deviation from Straight
		Y (max.) in degrees
		Allowable deviation from straight, Y(max), in total length or in any 300 mm or longer chord segment of total length.
over	thru	
..	40.00	3°/m but not greater than 7°
40.00	80.00	1.5°/m but not greater than 5°
80.00	..	1°/m but not greater than 3°

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TABLE 16.20 Width—Tolerances—Sawed-Plate Bar—Electric Conductors

SPECIFIED WIDTH mm		TOLERANCE mm plus and minus
Over	thru	ALLOWABLE DEVIATION FROM SPECIFIED WIDTH
50.00	150.00	2.40
150.00	350.00	3.20

TABLE 16.22 Thickness, Width, Diameter—Tolerances—Extruded Rod and Bar—Electric Conductors

SPECIFIED THICKNESS WIDTH, OR DIAMETER mm		TOLERANCE ①—mm plus and minus
Over	thru	ALLOWABLE DEVIATION FROM SPECIFIED DIMENSION
3.20	6.30	0.18
6.30	12.50	0.20
12.50	20.00	0.23
20.00	25.00	0.25
25.00	40.00	0.30
40.00	50.00	0.36
50.00	100.00	0.60
100.00	150.00	0.86
150.00	200.00	1.10
200.00	250.00	1.65
250.00	300.00	1.90

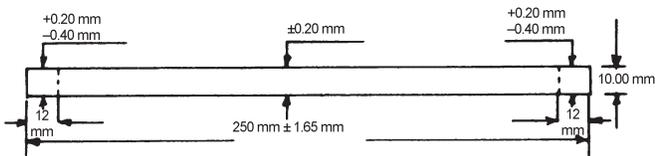
Footnotes for Tables 16.20 Through 16.23

① For some items of relatively thin wide bar greater thickness tolerances are required as follows:

- a. Specified bar thickness less than 12 mm; corner radii 1 mm or less; width to thickness ratio 24 to 1 and greater.

Tolerance per Table 16.22 except for distance 12 mm from each edge where plus tolerance of Table 16.22 applies and minus tolerance of 2 · Table 16.22 tolerance applies.

Example:



- b. Specified bar thickness 12 mm and greater; corner radii 5 mm or less; width to thickness ratio 10 to 1 and greater. Thickness tolerance per Table 16.22 except for distance 12 mm from edge where plus tolerance of Table 16.22 applies and minus tolerance 2 · Table 16.22 applies.

TABLE 16.21 Corners and Edges—Sawed Plate Bar—Electric Conductors

Edge surfaces and rough, showing saw marks, and corners are substantially square, with a slight burr.

TABLE 16.23 Length—Tolerances—Extruded Rod and Bar—Electric Conductors

SPECIFIED DIAMETER OR WIDTH mm		TOLERANCE—mm plus	
		ALLOWABLE DEVIATION FROM SPECIFIED LENGTH	
		SPECIFIED LENGTH—mm	
Over	thru	Up thru 5 000	Over 5 000 thru 10 000
..	70.00	4	7
70.00	200.00	6	9
200.00	..	7	10

TABLE 16.24 Flatness (Flat Surfaces)—Tolerances—Extruded Bar—Electric Conductors

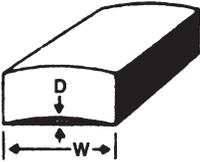
SPECIFIED WIDTH mm		TOLERANCE—mm	
		 Maximum Allowable Deviation D	
Over	thru		
..	25	0.10	
25	150	.004 · w(mm)	
In any 25 mm of length		0.10	

TABLE 16.26 Straightness ① ②—Tolerances—Extruded Rod and Bar—Electric Conductors

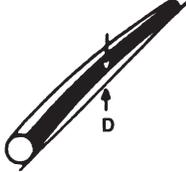
BAR		ROD		D(max) mm
TOLERANCE—mm		TOLERANCE—mm		
				Allowable deviation from straight, D(max), in total length or in any 300 mm or longer chord segment of total length.
D(max) in any 3 m length		Diameter mm		
Flatwise	Edgewise	over	thru	
6 mm	3 mm	10	150	1
		150	..	2

TABLE 16.25 Twist ③—Tolerances—Extruded Bar—Electric Conductors

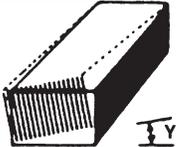
SPECIFIED WIDTH mm		TOLERANCE ②—DEGREES	
		ALLOWABLE DEVIATION FROM STRAIGHT	
		Y (max.) in degrees	
Allowable deviation from straight, Y(max), in total length or in any 300 mm or longer chord segment of total length.			
over	thru		
..	40.00	3°/m but not greater than 7°	
40.00	80.00	1.5°/m but not greater than 5°	
80.00	..	1°/m but not greater than 3°	

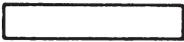
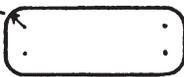
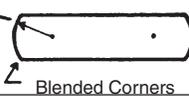
TABLE 16.27 Angularity—Extruded Bar—Electric Conductors

	
Allowable deviation from nominal angle: ±1 degree.	

TABLE 16.28 Squareness of Cut Ends—Extruded Rod and Bar—Electric Conductors

Allowable deviation from square: 1 degree.
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TABLE 16.29 Corner and Edge Radii—Tolerances—Extruded Bar—Electric Conductors

	SPECIFIED EDGE CONTOUR	SPECIFIED BAR THICKNESS mm		NOMINAL RADIUS	RADIUS TOLERANCE
		over	thru		
Square Corners		3.20 25.00	25.00 ..	.. ..	+1 mm +2 mm
Round Corners	Radius 	3.20 5.00 25.00	5.00 25.00 ..	1 mm 2 mm 4 mm	±0.5 mm ±0.5 mm ±0.5 mm
Rounded Edge	Radius  Blended Corners	.. 4.00	4.00 ..	1.25 · Bar thickness 1.25 · Bar thickness	±0.5 mm ±10%
Full Rounded Edge	Radius 	.. 10.00	10.00 ..	0.5 · Bar thickness 0.5 · Bar thickness	±0.5 mm ±10%

Footnotes for Tables 16.24 Through 16.29

- ① Deviation from straightness shall be checked as follows: Place the bar or rod on a level surface so that the departure from straightness is horizontal. Measure the maximum depth of arc to the nearest 0.8 mm using a steel scale and a 3-metre long straightedge.
- ② When mass of bar on flat surface minimizes deviation.
- ③ Twist is normally measured by placing the product on a flat surface and at any point along its length measuring the maximum distance between the bottom surface of the section and the flat surface. From this measurement, the actual deviation from straightness of the section at that point is subtracted. The remainder is the twist. To convert the standard twist tolerance (degrees) to an equivalent linear value, the sine of the standard tolerance is multiplied by the width of the surface of the section that is on the flat surface.

The following values are used to convert angular tolerance to linear deviation:

Tolerance Degrees	Max. Allowable Linear Deviation mm/mm of Width
0.25	0.004
0.5	0.009
1	0.017
1.5	0.026
3	0.052
5	0.087
7	0.122
9	0.156
15	0.259
21	0.358

Table 16.30 intentionally blank**Pipe****TABLE 16.31 Outside Diameter—Tolerances—Pipe—Electric Conductors**

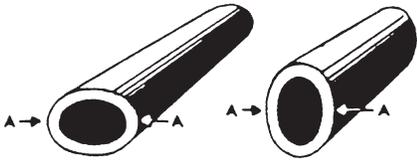
PIPE SIZE DESIGNATION	TOLERANCE—mm	
	ALLOWABLE DEVIATION OF DIAMETER AT ANY POINT FROM NOMINAL DIAMETER ① ② ④	
	 <p>Difference between AA and nominal diameter</p>	
SCHEDULE 40 or 80		
Under 2	+0.40	-0.80
2-4	+1%	-1%
5-7	+1%	-1%
8-12	+1%	-1%

TABLE 16.32 Wall Thickness—Pipe—Electric Conductors

Allowable deviation of wall thickness at any point from nominal wall thickness ①: minus 12.5 percent. (Maximum wall thickness is controlled by weight tolerance.)

Footnotes for Tables 16.31 Through 16.35

- ① Nominal diameter and wall thickness are those listed in Table 12.55.
 ② Not applicable to annealed (O temper) pipe.
 ③ When mass of piece on flat surface minimizes deviation.
 ④ The one percent tolerances are rounded to the nearest 0.1 mm before applying the tolerance.

TABLE 16.33 Straightness—Tolerances—Pipe—Electric Conductors

PIPE SIZE DESIGNATION	TOLERANCE ③—mm	
	ALLOWABLE DEVIATION FROM STRAIGHT	
	 <p>D (max.)</p>	
Allowable deviation from straight, D(max), in total length or in any 300 mm or longer chord segment of total length.		
Under 6	1 mm/m	
6-12	2 mm/m	

TABLE 16.34 Length—Tolerances—Pipe—Electric Conductors

Allowable deviation from specified length: plus 6 mm. Applies only in lengths up through 6 000 mm.

TABLE 16.35 Weight—Pipe—Electric Conductors

Allowable deviation from theoretical weight: plus 8 percent. (Minimum mass is controlled by tolerances for outside diameter and wall thickness.)